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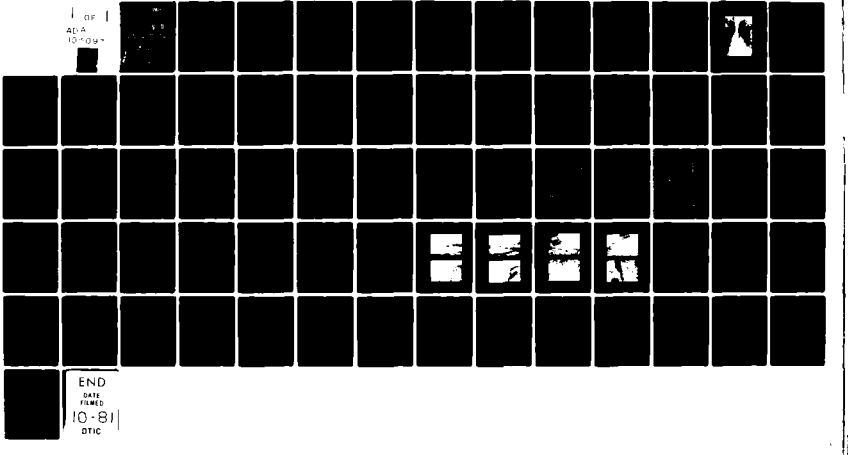

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MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

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POWDER SPRING LAKE DAM

WASHINGTON COUNTY, MISSOURI

MO 30749

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

MARCH 1980

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

POWDER SPRING LAKE DAM

WASHINGTON COUNTY, MISSOURI

MO 30749

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

MARCH 1980

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Powder Spring Lake Dam (Mo. 30749) Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Powder Spring Lake Dam:

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

1. Spillway will not pass 50 percent of the Probable Maximum Flood.

2. Overtopping of the dam and/or erosion of the spillway could result in failure of the dam.

3. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED
Chief, Engineering Division

8 APR 1980
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer

10 APR 1980
Date

POWDER SPRING DAM - MISSOURI INVENTORY NO. 30749

WASHINGTON COUNTY, MISSOURI

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

HORNER & SHIFRIN, INC.
5200 OAKLAND AVENUE
ST. LOUIS, MISSOURI 63110

FOR:

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS

MARCH 1980

HS-7925

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Powder Spring Lake Dam
State Located:	Missouri
County Located:	Washington
Stream:	Bust Branch of Mill Creek
Inspection Date:	17 July 1979

The Powder Spring Lake Dam was visually inspected by engineering personnel of the office of Horner & Shifrin, Inc., Consulting Engineers, St. Louis, Missouri. The purpose of the inspection was to assess the general condition of the dam with respect to safety and, based upon this inspection and available data, determine if the dam poses a hazard to human life or property.

The following summarizes the findings of the inspection and the results of certain hydrologic/hydraulic investigations performed under the direction of the inspection team. Based on the visual inspection and the results of these hydrologic/hydraulic investigations, the present general condition of the dam is considered to be somewhat less than satisfactory. The following deficiencies were noticed during the inspection and are considered to have an adverse effect on the overall safety and future operation of the dam and spillway.

1. A dense cover of brush that may conceal animal burrows and numerous small-and medium-size trees are present on the downstream face of the dam. The upstream face of the dam is also covered with small trees and brush that includes at least one animal burrow. Tree roots and animal burrows can provide

passageways for seepage that could develop into a piping condition (progressive internal erosion) and subsequent failure of the dam.

2. The spillway channel contains brush and numerous small trees. This growth obstructs channel flow and reduces capacity that could result in spillway releases overflowing the channel and impinging on the dam.

3. The left side of the spillway channel is extensively eroded and a near vertical bank exists at a location adjacent to the dam. Erosion of the bank can lead to an unstable slope and an earth slide that could block the spillway channel. In addition, loss of embankment material may impair the structural integrity of the dam.

4. A pool, believed to be due in part to backwater from the downstream channel, Bust Branch, abuts the downstream toe of the dam. The presence of the pool creates an unnecessarily high tailwater which is a condition considered to be unfavorable to the structural stability of the dam. The pool also prevents control of dam underseepage if such a condition exists.

5. The handle for the control valve on the south drawdown pipe is broken and the outlet end of the north drawdown pipe is either buried or submerged. These conditions impose constraints on functioning of the drawdown facilities as planned.

The conditions described above are not considered to be of major consequence to warrant immediate remedial action.

According to the criteria set forth in the recommended guidelines (see text) the minimum spillway design flood for this dam, which is classified as small in size and of high hazard potential, is specified to be a minimum of 1/2 the Probable Maximum Flood (PMF). Considering the

fact that four habitable buildings lie within the downstream damage zone, it is recommended that the spillway design flood for this structure be the PMF. PMF is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF is ordinarily accepted as the inflow design flood for dams where failure of the structure would increase the danger to human life.

Results of a hydrologic/hydraulic analysis indicate that the existing spillways (principal and emergency) are inadequate to pass lake outflow resulting from a storm of PMF magnitude or the lake outflow from the 1 percent chance (100-year frequency) flood without overtopping the dam. They are adequate however, to pass the lake outflow resulting from the 0.1 percent chance (10-year frequency) flood and the lake outflow corresponding to about 12 percent of the PMF lake inflow. According to the St. Louis District, Corps of Engineers, the length of the downstream damage zone, should failure of the dam occur, is estimated to be two miles. Within the potential damage zone are four dwellings, a county road and a railroad bridge crossing.

A review of available data did not disclose that seepage and stability analyses of the dam were performed. This is considered a deficiency and should be rectified.

It is recommended that the Owner take the necessary action in the near future to correct or control the deficiencies and safety defects reported herein.

Karl L. Preese
P.E. Missouri E-16182

Albert B. Becker, Jr.
P.E. Missouri E-9168

OVERVIEW POLDER SPRUCE LAKE DAM

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

POWDER SPRING LAKE DAM - ID. NO. 30749

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PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

POWDER SPRING LAKE DAM - ID NO. 30749

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. National Dam Inspection Act, Public Law 92-367, dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, directed that a safety inspection of the Powder Spring Lake Dam be made.

b. Purpose of Inspection. The purpose of this visual inspection was to make an assessment of the general condition of the dam with respect to safety and, based upon available data and this inspection, determine if the dam poses a hazard to human life or property.

c. Evaluation Criteria. This evaluation was performed in accordance with the "Phase I" investigation procedures as prescribed in "Recommended Guidelines for Safety Inspection of Dams," Appendix D to "Report of the Chief of Engineers on the National Program of Inspection of Non-Federal Dams," dated May 1975.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances. The Powder Spring Lake Dam is an earthfill type embankment rising approximately 28 feet above the original streambed. The embankment has an upstream slope (above the waterline) of 1v on 2.1h, a crest width of about 12 feet, and an irregular downstream slope that varies from about 1v on 2.8h for the upper 12 feet to 1v on 3.5h for the lower 16 feet. The length of the dam

is approximately 418 feet. A plan and profile of the dam is shown on Plate 3 and a cross-section of the dam is shown on Plate 4. At normal pool elevation the reservoir impounded by the dam occupies approximately 13 acres.

The lake level is governed by overflow of a broad-crested weir type spillway that is cut through the hillside at the right (south) abutment. The spillway discharge channel, a trapezoidial section of variable width, follows a course along the right abutment and joins the downstream channel, Bust Branch, at a point about 200 feet below the dam. A shallow pool that appears to have been created by stream flow backwater, abuts the toe of the dam near the center of the embankment and extends downstream to about the point where the spillway channel joins Bust Branch. The pool is approximately one-half acre in surface area. A profile of the spillway channel invert is shown on Plate 4.

An emergency spillway, a shallow dish-shaped section, crosses the dam crest at the left (north) abutment. The outlet channel for the emergency spillway is not distinguishable, but apparently follows the junction of the embankment and the abutment.

Two 6-inch diameter pipes with control valves near their downstream ends are provided to dewater the lake. The drawdown pipes are located near the left center of the dam with their outlet ends at the pool below the dam.

b. Location. The dam and lake are located on Bust Branch, a tributary of Mill Creek, approximately 1.5 miles southeast of the town of Belle-Fontaine and 1.5 miles west of the town of Tiff, Missouri, as shown on the Regional Vicinity Map, Plate 1. The dam is located in Section 15, Township 38 North, Range 3 East, within Washington County.

c. Size Classification. The size classification, based on the height of the dam and storage capacity, is categorized as small. (Per Table 1, Recommended Guidelines for Safety Inspection of Dam.)

d. Hazard Classification. According to the St. Louis District, Corps of Engineers, the Powder Spring Lake Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, serious damage to homes, important public utilities, main highways, railroads, or extensive damage to agricultural, industrial or commercial facilities. The estimated flood damage zone, should failure of the dam occur, as determined by the St. Louis District, extends approximately two miles downstream of the dam. Within the possible damage zone are four dwellings, a county road, and a railroad bridge crossing.

e. Ownership. The dam is owned by Bernis M. Bone. Mr. Bone's address is Route 1, Box 497A, Cadet, Missouri 63630. Mr. Bone's residence is adjacent to the lake.

f. Purpose of Dam. The dam impounds water primarily for recreational purposes.

g. Design and Construction History. The dam was constructed for the Owner in 1964, by Mr. Kelly Smith, a local excavating and grading contractor, who no longer is in business. Efforts to contact Mr. Smith were unsuccessful. According to Mr. Bone, the laying out of the dam was done by Mr. Mel Means, a local contractor experienced in earth dam construction. Mr. Means, who no longer is in the contracting business, was contacted and stated that the layout of the dam and spillway was without the aid of any formal engineering or design data.

h. Normal Operational Procedure. The lake level is regulated by overflow of an earthen, broad-crested weir type spillway.

1.3 PERTINENT DATA

a. Drainage Area. The area tributary to the lake is extensively surface mined for barite. From the appearance of the terrain, it is evident that mining operations have been underway for many years. In all

there are four ponds formed by dams made from mine by-products within the drainage area upstream from Powder Spring Lake. As identified by the Corps of Engineers, these dams are Mo. 30707, Mo. 30704, Mo. 30750 and Mo. 30752. The pond impounded by Mo. 30707 covers an area of approximately 26 acres at normal operating level and is located approximately one mile upstream of the Power Spring Lake Dam. A second tailings pond dam, Mo. 30704, which impounds an area of about 10 acres at normal level, is located immediately to the southwest of Mo. 30707 and just east of State Highway E. Dam Mo. 30750 is located on Bust Branch approximately 1.5 miles upstream of the Powder Spring Dam and just west of State Highway E. The pond impounded by this dam occupies an area of about 38 acres at normal level. Mo. 30752 is located about 0.5 mile upstream of Mo. 30750. No surface area data for this impoundment were available. The area not affected by mining is for the most part in a natural state, covered with timber and/or native grasses. The watershed above the Powder Spring Lake Dam amounts to approximately 2,759 acres. The watershed area including the sub-watersheds for the upstream tailings pond dams, is outlined on the Watershed Map, Plate 2.

b. Discharge at Damsite.

(1) Estimated known maximum flood at damsite ... 410 cfs*

(2) Spillway capacity (principal) ... 1,490 cfs (W.S. Elev. 730.7)

(3) Spillway capacity (principal plus emergency) ... 1,920 cfs (W.S. Elev. 731.3)

c. Elevation (ft. above MSL). The crest of the principal spillway was assumed to be elevation 727.0 (feet above MSL); the basis for this assumption being the topographic data shown on the 1937 Tiff, Missouri, Quadrangle Map, 7.5 minute series.

(1) Top of dam ... 731.3 (min.)

(2) Normal pool (crest principal spillway) ... 727.0

(3) Streambed at centerline of dam ... 706±

*Value computed for water surface at elevation 728.5 and based upon an estimate of maximum depth of flow at the principal spillway as provided by the Owner.

(4) Maximum tailwater ... Unknown

(5) Tailwater at time of inspection ... 705.7

d. Reservoir.

(1) Length at normal pool (Elev. 727.0) ... 2,000 ft.

(2) Length at maximum pool (Elev. 731.3) ... 2,300 ft.

e. Storage.

(1) Normal pool ... 107 ac.ft.

(2) Top of dam (incremental) ... 67 ac.ft.

f. Reservoir Surface.

(1) Normal pool ... 13 acres

(2) Top of dam (incremental) ... 5 acres

g. Dam.

(1) Type ... Earthfill, homogeneous*

(2) Length ... 418 ft.

(3) Height ... 28 ft.

(4) Top width ... 12 ft.

(5) Side slopes

a. Upstream ... 1v on 2.1h (above waterline)

b. Downstream ... Irregular, 1v on 2.8h (upper), 1v on 3.5h (lower)

(6) Cutoff ... Core trench*

(7) Slope protection ... Grass, upstream and downstream

h. Principal Spillway.

(1) Type ... Excavated earth, broad-crested trapezoidal section

(2) Location ... Right abutment

(3) Crest .. Elevation 727.0

(4) Approach channel ... Lake

(5) Discharge Channel ... Earth and rock cut, trapezoidal section

*Per Owner

i. Emergency Spillway.

(1) Type ... Earth, broad-crested, dish-shaped section

(2) Location ... Left abutment

(3) Crest ... Elevation 730.7

(4) Approach channel ... Lake

(5) Discharge channel ... Earth, V-section

j. Outlet for Lake Drawdown.

(1) Number/size ... Two 6-inch steel pipes

(2) Control ... Valves, at outlet end of pipes

(3) Invert elevation at outlet:

a. Right side pipe ... Elevation 705.9

b. Left side pipe ... Outlet not located

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No engineering data relating to the design of the dam are known to exist. According to the Owner, the dam was laid out by a Mr. Mel Means, a local contractor experienced in the planning and construction of earthen dams. Mr. Means was contacted and he reported that the basis of his layout (design) for this dam was empirical, based on experience and judgment. Mr. Means mentioned that the spillway proportions were based on a known high water mark at the dam location.

2.2 CONSTRUCTION

According to the Owner, the builder of the dam was a Mr. Kelley Smith, a local excavating contractor. Efforts to contact Mr. Smith were unsuccessful. According to the Owner, the dam was constructed with a core trench seepage cutoff that extended about 4-to-5 feet below the original ground surface to rock. The Owner also reported that the trench and embankment were constructed of material, red clay, obtained from the area to be occupied by the lake and that compaction was achieved by running the earth hauling equipment over the previously placed fill layer. According to the Owner, the dam is 165 feet wide at the base, 12 feet wide at the crest, the upstream face has a slope of 1v on 3h, and the downstream face has a slope of 1v on 2h, although some additional fill was added to the lower part of the dam to widen the base of the structure and as a result, the slope of the lower part of the dam is flatter than 1v on 2h. A cross-section of the embankment taken near the high point of the dam and based on survey data indicated the exposed upstream face to have a slope of 1v on 2.1h, the crest width to be 12 feet, and the downstream face to have a slope of 1v on 2.8h for the upper 12 feet and 1v on 3.5h for the remaining downslope.

2.3 OPERATION

The lake level is governed by overflow of an excavated earth spillway. According to the Owner who resides adjacent to the lake, the dam has not been overtopped and the estimated maximum known loading on the dam was caused by a storm that produced a depth of flow at the spillway crest of about 18 inches.

Barite mining operations are being carried out by NL Industries in the area upstream of the dam. A mine tailings pond is located in a valley approximately 1 mile upstream of the dam. Several other tailings ponds are also located upstream of the lake. The respective locations of these tailings ponds are shown on Plate 2. Siltation, apparently due to fines carried by flow from the tailings ponds, is evident at the upstream end of the lake. The Owner, Mr. Bone, when interviewed during the inspection, expressed concern for the adequacy of the upstream tailings pond dam spillways. Mr. Bone reported that this last spring (1979), after experiencing rainfalls of about 5 and 6 inches on consecutive days, a representative of the mining company advised him and his family to leave their home and seek higher ground since it appeared that one of the upstream mine tailings dams was about to be overtopped. The dam, however was not overtopped, and they returned to their home shortly thereafter.

2.4 EVALUATION

a. Availability. Engineering data for assessing the design of the earthfill dam and spillway were unavailable.

b. Adequacy. No data available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the Powder Spring Lake Dam was made by Horner & Shifrin engineering personnel, K. L. Freese, Civil Engineer and Hydrologist, and A. B. Becker, Jr., Civil and Soils Engineer, on 17 July 1979. An examination of the dam site was also made by an engineering geologist, Jerry D. Higgins, a consultant retained by Horner & Shifrin for the purpose of assessing the area geology. Also examined at the time of the inspection, was the area below the dam within the potential flood damage zone. Photographs of the dam taken at the time of the inspection are included on Pages A-1 through A-4 of Appendix A. The locations of the photographs taken during the inspection are shown on Plate 3.

b. Geology. The dam and lake are located on the northern flank of the Ozark Uplift and are underlain by the Potosi formation. The Potosi is a massive, thickly-bedded, medium-to fine-grained dolomite with abundant quartz druse and chert. The unconsolidated materials are typical Potosi residuum, a red, blocky clay with much chert and quartz druse.

The right bank of the reservoir has a relatively gentle slope and appears to be underlain by residuum of considerable thickness whereas the left bank is steeper and is characterized by thin residuum and bedrock outcrops. The banks on both sides of the lake are stable and no evidence of slumping or excessive erosion was observed.

Bedrock is exposed on both abutments at the dam site. The outcrops are highly jointed and have been subject to considerable solution weathering and solution enlargement of the fractures. Some standing water was observed at the toe of the dam. No water was noticed flowing from either abutment or valley side downstream of the dam.

Powder Spring Lake is partially spring fed and three springs exist in the immediate vicinity. Two of these springs are now submerged by the reservoir, but the third, located further upstream, continues to flow. The presence of the springs and the unusually straight course of Burt Branch through this area suggests that the stream may be fault controlled. However, since there is no evidence of displacement, since the area is not considered tectonically active, and since there apparently are no fault-related geotechnical problems related to dam or reservoir performance, the possible existence or non-existence of a fault is not considered significant. Geologic conditions at the site do not appear to influence the performance of the dam or reservoir.

c. Dam. The visible portions of the upstream and downstream faces of the dam (see Photos 1 and 2) appeared to be in sound condition although some minor erosion of the unprotected upstream slope at the waterline was noticed and an animal burrow was observed in the upstream face of the dam near the left abutment. Both the upstream and downstream faces of the dam were covered with brush and numerous small-to-medium size trees. No surface cracks were noticed in the crest or faces of the dam, nor was there any indication of seepage at the abutments or downstream face of the dam. Since a pool of water (see Photo 6) of about one-half acre abuts the downstream toe of slope, it could not be determined if an underseepage condition exists.

Of the two 6-inch steel drawdown pipes that extend through the dam and emerge near the downstream toe, only the pipe outlet on the right (south) side could be seen. The pipe outlet on the left (north) side was not exposed to view and is either buried or submerged in the pool that adjoins the dam. Both control valves were well protected from the weather by metal covers and bales of straw. The valve handle on the right side pipe was broken (see Photo 7) and the valve on the left side pipe was housed in a steel enclosure (see Photo 8) and submerged. It was not determined if either valve was functional.

d. Principal Spillway. The general condition of the excavated earth principal spillway was found to be satisfactory. There was, however, a

minor accumulation of driftwood and cattails (see Photo 3) on the approach side of the spillway crest. The spillway outlet channel is in earth and rock cut for approximately 100 feet before the invert encounters a series of rock falls. Small trees and brush (see Photo 4) are prevalent throughout this section of the channel. The outlet channel continues until it reaches the original stream, Bust Branch, at a point about 200 feet below the dam. At a location opposite the centerline of the dam, the left bank of the outlet channel is extensively eroded (see Photo 5) and a vertical slope of about 10 feet exists. From the condition of the exposed earthen bank at this location, it appeared that the upper 2 feet or so, was fill ground.

e. Emergency Spillway. The crest of the emergency spillway consists roughly of a dish-shaped section formed by the junction of the dam and the left abutment. The lake approach to the spillway was grown over with cattails and brush. The outlet channel, although not distinguishable, presumably follows the junction of the embankment with the left abutment and was covered with brush and numerous small trees.

f. Downstream Channel. The channel, Bust Branch, downstream of the dam is unimproved and extends for approximately 2 miles before joining Mill Creek. A bridge belonging to the Missouri Pacific Railroad crosses Bust Branch just upstream of the confluence with Mill Creek.

g. Reservoir. The area adjoining the right side of the lake was well maintained with several homes and other buildings along the shoreline near the lake. The area along the left side of the lake is mostly hillside and in a natural state covered with timber. Silt that appeared to be mining waste, was noticed in the lake at the very upstream end. The amount of mining waste sediment within the lake could not be determined at the time of the inspection, but it did not appear to be significant.

3.2 EVALUATION

The deficiencies observed during the inspection are not considered significant to warrant immediate remedial action.

It is probable that the pool that exists below the dam is backwater from flooding of the downstream channel. However, the likehood of a dam underseepage condition with water from the lake supplying the pool cannot be discounted.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The spillways are uncontrolled. The water surface level is governed by precipitation runoff, evaporation, seepage, and the capacities of the uncontrolled spillways. The lake level is also affected by spillway releases of the several upstream tailings ponds.

4.2 MAINTENANCE OF DAM

Based on the substantial cover of brush and trees on the upstream and downstream faces of the dam as well as the extensive growth of brush and small trees in the spillway channel, it is apparent that these areas could receive additional attention. The Owner did report that some trees were cleared from the dam area last winter (1978).

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

With the exception of the two lake drawdown pipes, no outlet operating facilities exist at this dam. As indicated in Section 3, Paragraph 3.1 c, the operating handle on the valve for the right side drawdown pipe is broken and the outlet end of the left side drawdown pipe could not be located.

4.4 DESCRIPTION OF ANY WARNING SYSTEMS IN EFFECT

The inspection did not reveal the existence of a dam failure warning system.

4.5 EVALUATION

Lack of or inadequate maintenance is considered detrimental to the safety of a dam. It is recommended that maintenance of the dam, including the principal and emergency spillways including their outlet channels, be undertaken on a regular basis. The broken valve handle for

the drawdown pipe on the right side should be repaired and both valves inspected and their performance checked. It is also recommended that the outlet for the drawdown pipe on the left side be uncovered.

SECTION 5 - HYDROLOGIC/HYDRAULIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data are not available.

b. Experience Data. The drainage area and lake surface area were developed from the USGS Tiff, Missouri Quadrangle Map. The proportions and dimensions of the spillways and dam were developed from surveys made during the inspection.

No records of rainfall, stream flow, or flood data for the watershed were available. Phase I dam safety inspection reports for the upstream tailings pond dams (30707, 30704 and 30750) were provided by the St. Louis District, Corps of Engineers. As indicated herein, certain hydrologic data contained in these reports was utilized in the investigations of overtopping of the Powder Spring Lake Dam.

c. Visual Observations.

(1) The principal spillway consists of an approximately trapezoidal section cut into the hillside at the right (south) abutment. An earthen berm that adjoins the dam directs flow to the spillway crest which is located approximately 100 feet upstream of the dam.

(2) The outlet channel of the principal spillway consists of a trapezoidal section with a minimum bottom width of approximately 30 feet. The sides of the channel are irregular and eroded with a near vertical bank existing at the section adjacent to the dam. Jagged rock outcroppings of the Potosi formation are exposed in the invert of the channel. The spillway channel drops abruptly over a series of rock falls at a point approximately 25 feet downstream of the center of the dam. The spillway channel joins the downstream channel, Bust Branch, at a point about 200 feet below the dam.

(3) The emergency spillway consists of a shallow dish-shaped depression located at the junction of the embankment and left (north) abutment. The discharge channel for the emergency spillway appears to follow the junction of the embankment and the hillside having its outlet at the backwater pool that lies just downstream of the dam.

(4) Drawdown facilities consisting of two 6-inch diameter steel pipes pass through the left side of the embankment. One of the pipes is equipped with a valve housed in a buried 55 gallon drum while the other valve is protected from the elements by several layers of straw.

d. Overtopping Potential. Elevation 731.3 was determined to be the low point in the dam crest. The spillways (principal and emergency) are inadequate to pass the probable maximum flood, 1/2 the probable maximum flood or the 1 percent chance (100-year frequency) flood without overtopping the dam. They are adequate, however, to pass the 0.1 percent chance (10-year frequency) flood without overtopping the dam. Results of the overtopping analysis are summarized as follows:

Ration of PMF	Q-Peak Outflow (cfs)	Max. Lake W.S. Elev.	Max. Depth (Ft.) of Flow Over Dam (Elev. 731.3)	Duration of Overtopping of Dam (Hrs)
0.12*	1,920	731.3	0.0	0.0
0.50	10,313	734.8	3.5	6.7
1.00	21,722	737.2	5.9	9.4
100-Yr. Flood	2,242	731.6	0.3	0.4
10-Yr. Flood	1,007	729.8	0.0	0.0

The flow safely passing the spillways just prior to overtopping was determined to be 1,920 cfs, which amounts to approximately 12 percent of the probable maximum flood inflow. This flow is greater than the outflow for the 0.1 percent chance (10-year frequency) flood. During peak flow of the probable maximum flood, the greatest depth of flow over the dam would be 5.9 feet and the overflow will extend along the entire length of the dam crest.

*To nearest one-hundredth

The inflow hydrograph used in the overtopping analyses includes the outflow from the upstream mine tailings ponds (30707, 30704, 30750 and 30752) as indicated in the Phase I dam safety inspection reports of these dams prepared by International Engineering Company, Inc., Consulting Engineers, San Francisco, California. In these analyses and the analysis for the Powder Spring Lake Dam it was assumed that none of the upstream dams had failed, although the analyses indicated that the dams would be overtopped when the PMF occurs.

e. Evaluation. Experience indicates that the residuum, a gravelly red clay, can under certain conditions, such as high velocity flow, be very erodible. Evidence of such erosion was observed at the principal spillway. Such a condition exists during the PMF, when large lake outflow with corresponding high velocities occur both at the spillways and over the top of the dam. Since the depth of flow overtopping the dam, (5.9 feet maximum) and the duration of flow over the dam (8.4 hours), are substantial, serious damage by erosion due to overtopping of the dam is likely. The extent of these damages is not predictable, however, there is the possibility that they could result in failure of the dam.

f. References. Procedures and data for determining the probable maximum flood, the 100-year frequency flood, the 10-year frequency flood and the discharge rating curve for flow over the spillway and dam crest are presented on Pages B-1 and B-2 of the Appendix. A listing of the HEC-1 (Dam Safety Version) input data is shown on Pages B-3 thru B-14 of the Appendix. A copy of the computer output table entitled "Summary of Dam Safety Analysis" is presented on Page B-15 and the inflow and outflow hydrographs for the probable maximum flood shown on Page B-16 of the Appendix. Area-storage volume curves for the reservoir are shown on Plate 5 and a spillway rating curve is presented on Plate 6.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations which adversely affect the structural stability of the dam are discussed in Section 3, paragraph 3.1c.

b. Design and Construction Data. No design or construction data relating to the structural stability of the dam are known to exist.

c. Operating Records. With the exception of the valves on the two 6-inch diameter lake drawdown pipes, no appurtenant structures or facilities requiring operation exist at this dam. According to the Owner, no records are kept of lake level, spillway discharge, dam settlement, or seepage.

d. Post Construction Changes. According to the Owner, there have been no post construction changes which would affect the structural stability of the dam.

e. Seismic Stability. The dam is located within a Zone II seismic probability area and an earthquake of the magnitude predicted for this area is not expected to produce a hazardous condition to the dam, provided that static stability conditions are satisfactory and conventional safety margins exist.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several items were noticed during the visual inspection that adversely affect the safety of the dam. Included in these items are the trees and brush which exist on both the upstream and downstream faces of the dam. In addition, the left bank of the principal spillway channel at the section adjacent to the dam was overly steep and badly eroded; the upstream face of the dam had only a turf cover to prevent erosion; and, a hole, believed to be an animal burrow, was observed in the upstream face of the dam.

A hydraulic analysis indicated that the principal and emergency spillways are capable of passing lake outflow of about 1,920 cfs without the level of the lake exceeding the low point of the dam crest. A hydrologic analysis of the lake watershed area, as discussed in Section 5, indicated that for storm runoff of probable maximum flood magnitude the lake outflow would be on the order of 21,772 cfs, the lake outflow for the 100-year frequency flood would be about 2,242 cfs, and the lake outflow for the 10-year frequency flood would be approximately 1,007 cfs.

Seepage and stability analyses of the dam were not available for review and therefore no judgment could be made with respect to the structural stability of the dam.

b. Adequacy of Information. Due to the lack of design and construction data, the assessments reported herein were based on external conditions as determined during the visual inspection. The assessment of the hydrology of the watershed and capacities of the spillways were based on a hydrologic/hydraulic study as indicated in Section 5. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. The items concerning the safety of the dam noted in paragraph 7.1a and the remedial measures recommended in paragraph 7.2 should be accomplished within a reasonable time.

d. Necessity for Phase II. Based on the results of the Phase I inspection, a Phase II investigation is not recommended.

e. Seismic Stability. The dam is located within a Zone II seismic probability area and an earthquake of the magnitude predicted for this area is not expected to produce a hazardous condition to the dam, provided that static stability conditions are satisfactory and conventional safety margins exist.

7.2 REMEDIAL MEASURES

a. Recommendations. The followings actions are recommended:

(1) Based upon the criteria set forth in the recommended guidelines, alterations to the design of the dam should be made in order to pass lake outflow resulting from a storm of probable maximum flood magnitude.

(2) Obtain the necessary soil data and perform dam seepage and stability analyses (comparable to the requirements of the guidelines) in order to determine the structural stability of the dam for all operational conditions. Seepage and stability analyses should be performed by a qualified professional engineer experienced in the design and construction of earthen dams.

b. Operations and Maintenance (O & M) Procedures. The following O & M procedures are recommended:

(1) Remove the trees and brush from the upstream and downstream faces of the dam. Fill the animal burrow that exists in the upstream

face of the dam. Tree roots and animal burrows provide passageways for seepage that can lead to a piping condition and possible failure of the dam. The turf cover should be restored if destroyed or missing. Maintain the turf cover on the embankment at a height that will not hinder inspection of the dam or harbor burrowing animals. The removal of trees should be performed under the direction and guidance of an engineer experienced in the design and construction of earthen dams, since indiscriminate clearing can jeopardize the safety of the dam.

(2) Remove the trees and brush from the principal spillway channel in order to allow flow to reach the downstream channel unrestricted. Obstructions within the spillway will restrict flow and reduce the carrying capacity of the outlet channel which could result in flooding of the embankment adjacent to the spillway and/or overtopping of the dam.

(3) Restore the eroded left bank of the principal spillway channel in the area adjacent to the dam and provide some form of protection that will prevent future erosion of the bank by spillway releases. Continued erosion of the bank could be detrimental to the structural stability of the embankment.

(4) Drain the pool that abuts the downstream toe of the dam and provide some means of preventing future ponding of water in the area below the dam. The presence of the pool at the base of the dam is a condition considered to be unfavorable to the structural stability of the dam since saturation of the soil weakens the strength of the foundation. It also prevents control of dam underseepage if such a condition exists.

(5) Provide some form of protection (other than grass) for the upstream face of the dam at and above the normal waterline in order to prevent erosion by wave action. A grass covered slope is not considered adequate protection to prevent erosion of the embankment by wave action or by fluctuations of the lake surface level.

(6) Repair the broken handle for the control valve on the south drawdown pipe and uncover the outlet for the north drawdown pipe in order that these facilities may function as intended.

(7) Provide maintenance of all areas of the dam and spillway on a regularly scheduled basis in order to insure features of being in satisfactory condition.

(8) A detailed inspection of the dam should be instituted on a regular basis by an engineer experienced in the design and construction of dams. It is also recommended, for future reference, that records be kept of all inspections made and remedial measures taken.

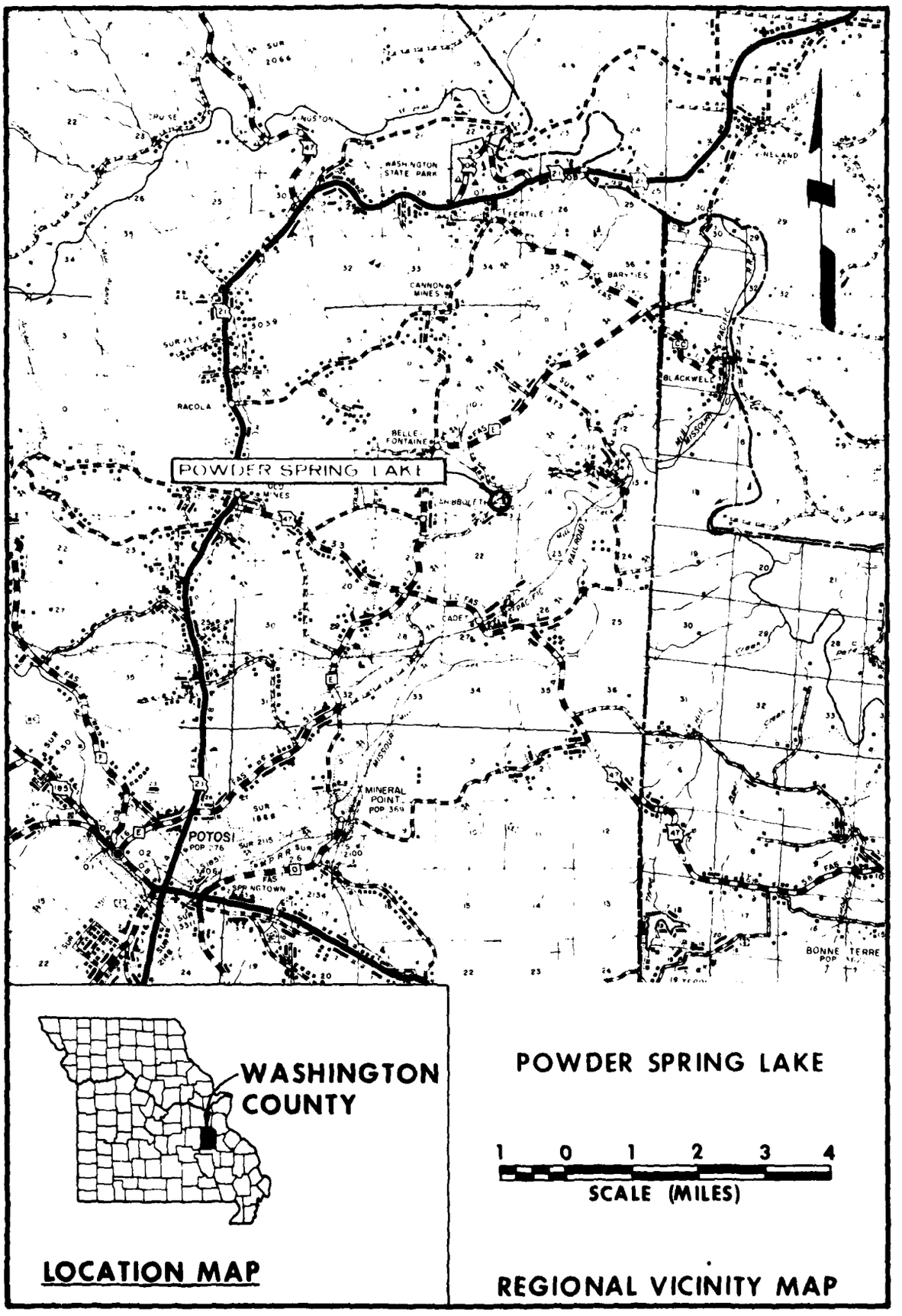
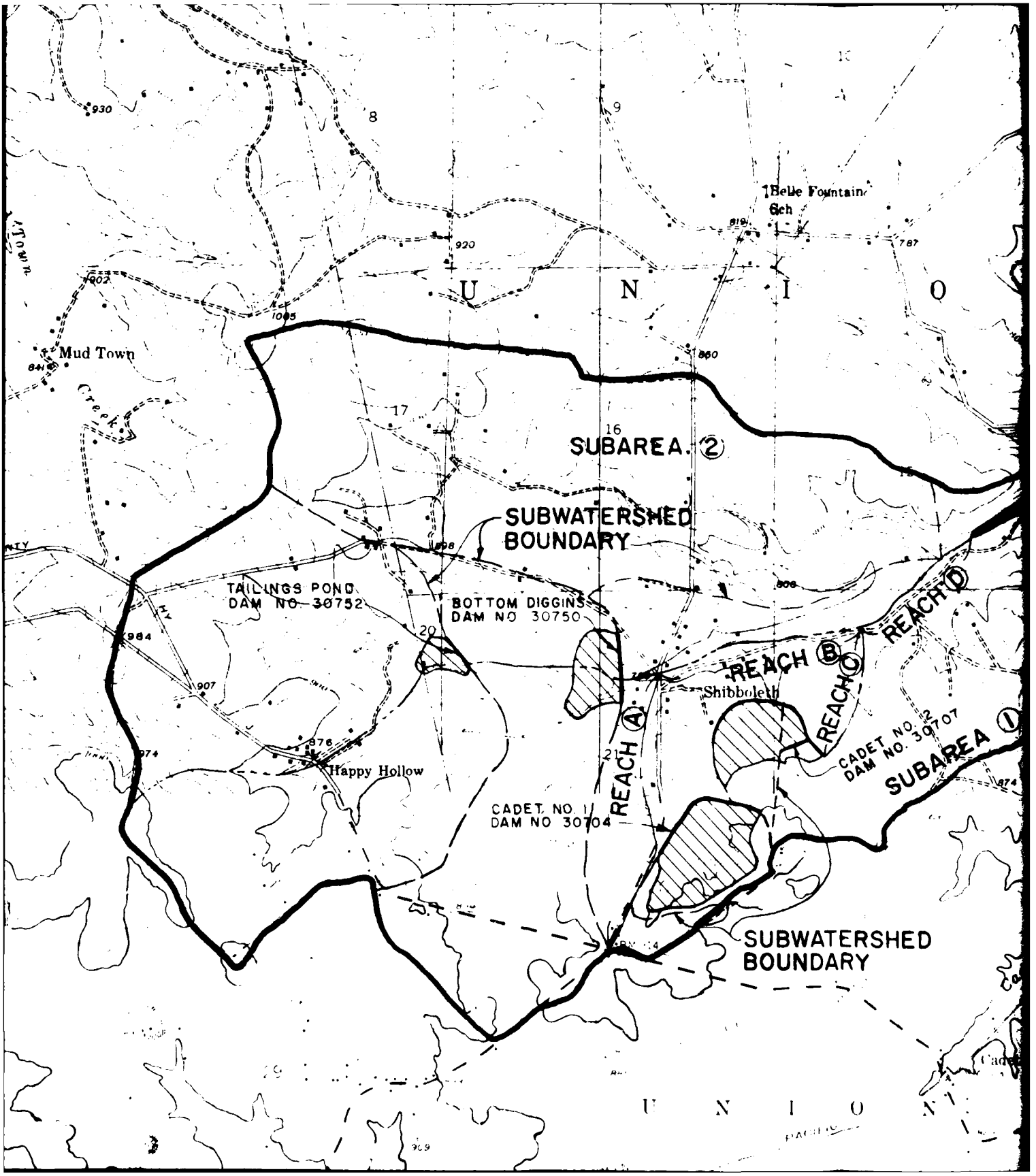
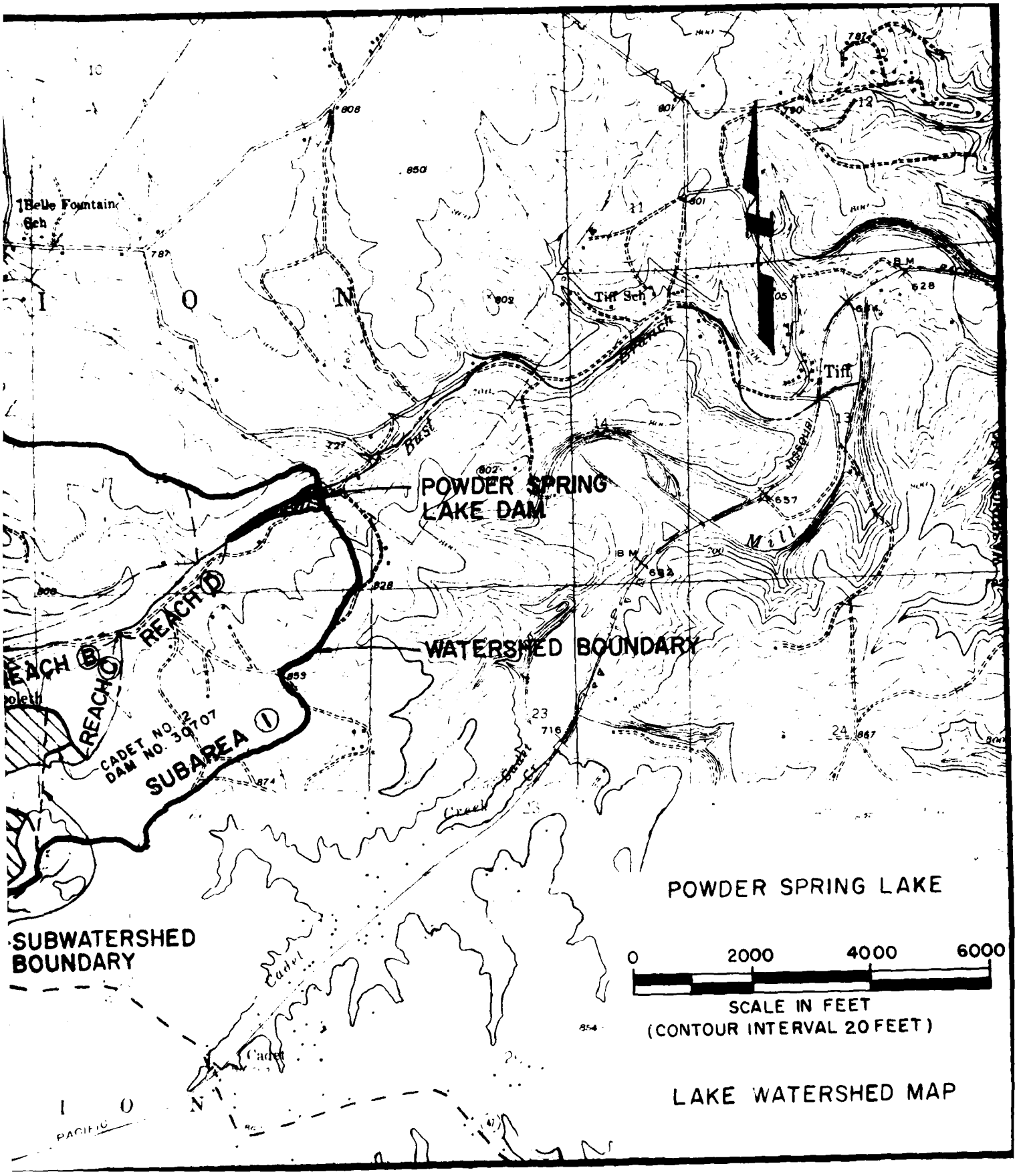
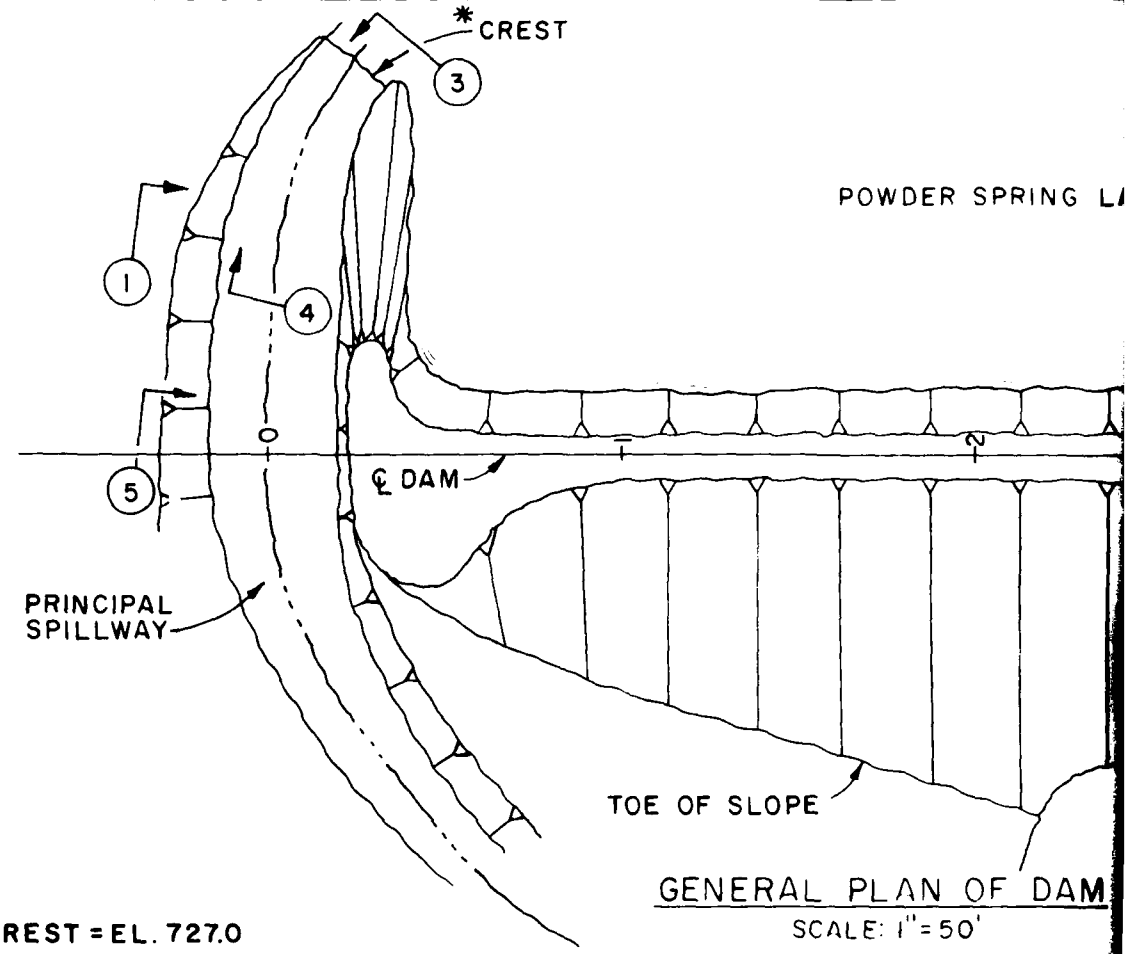

POWDER SPRING LAKE
WASHINGTON STATE PARK
FERTILE
CANNON MINES
BARRYTIES
BLACKWELL
RACOLA
BELLE FONTAINE
SHIBBOLETH
CADET
MINERAL POINT POP 369
POTOSI POP 776
SPRINGTOWN
BONNE TERRE
WASHINGTON COUNTY
LOCATION MAP
POWDER SPRING LAKE
1 0 1 2 3 4
SCALE (MILES)
REGIONAL VICINITY MAP

PLATE 1

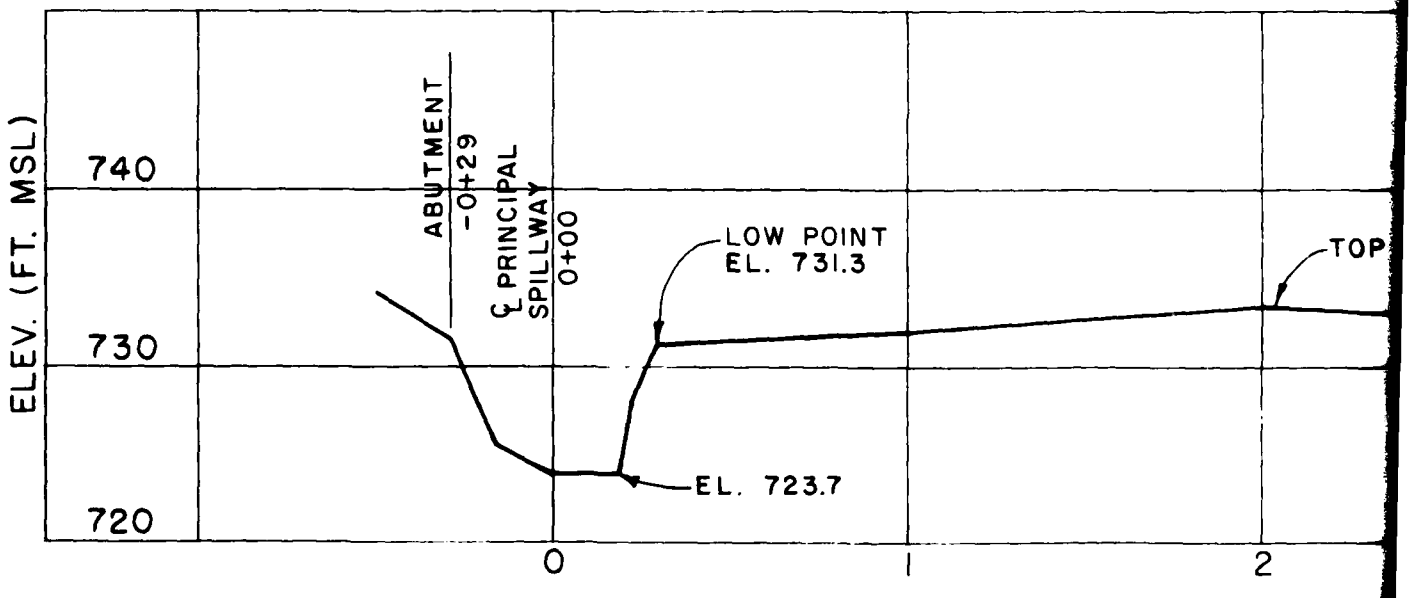

Belle Fountain
Sch
U N I O
Mud Town
SUBAREA (2)
SUBWATERSHED
BOUNDARY
TAILINGS POND
DAM NO 30752
BOTTOM DIGGINS
DAM NO 30750
REACH (B)
REACH (C)
REACH (D)
Shibboleth
REACH (A)
CADET NO 2
DAM NO 30707
SUBAREA (1)
Happy Hollow
CADET NO 1
DAM NO 30704
SUBWATERSHED
BOUNDARY
U N I O N


POWDER SPRING LAKE DAM
WATERSHED BOUNDARY
REACH D
REACH C
REACH B
SUBAREA 1
CADET NO. 2 DAM NO. 30707
SUBWATERSHED BOUNDARY
Belle Fountain Sch
Tiff Sch
Tiff
Mill
Cadet
POWDER SPRING LAKE
0 2000 4000 6000
SCALE IN FEET
(CONTOUR INTERVAL 20 FEET)
LAKE WATERSHED MAP



POWDER SPRING LA

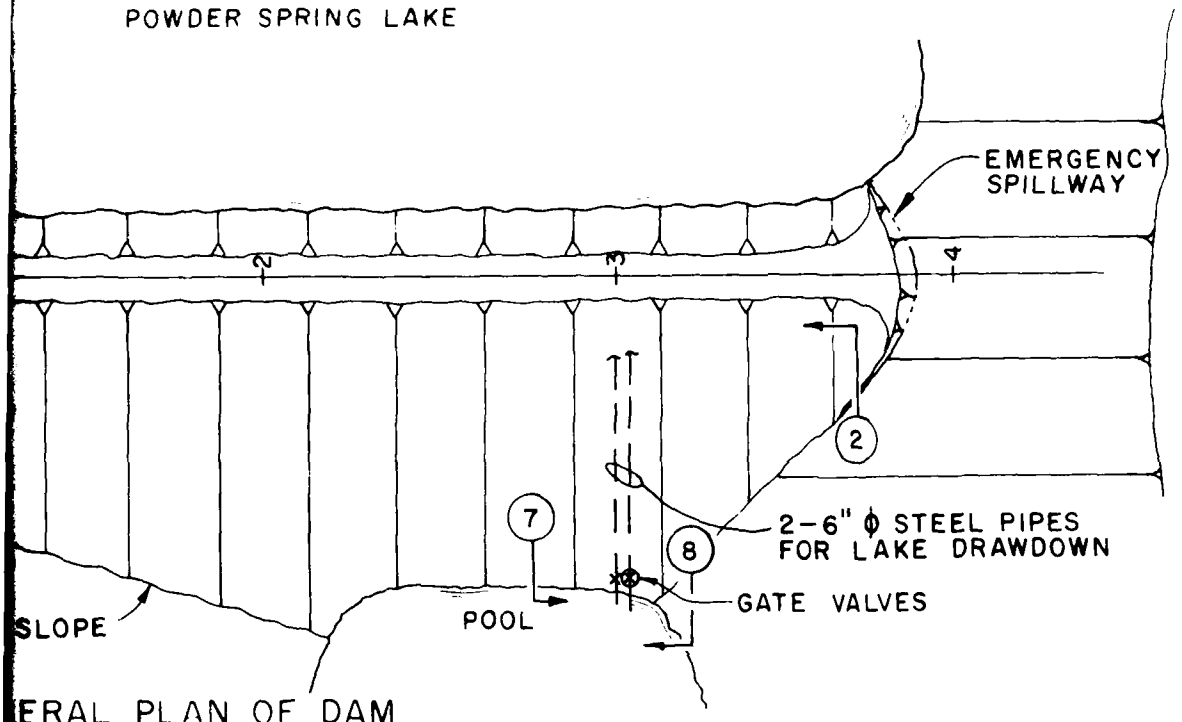
GENERAL PLAN OF DAM
SCALE: 1" = 50'



PROFILE DAM CENTERLI
SCALES: 1" = 10' V., 1" = 50' H.

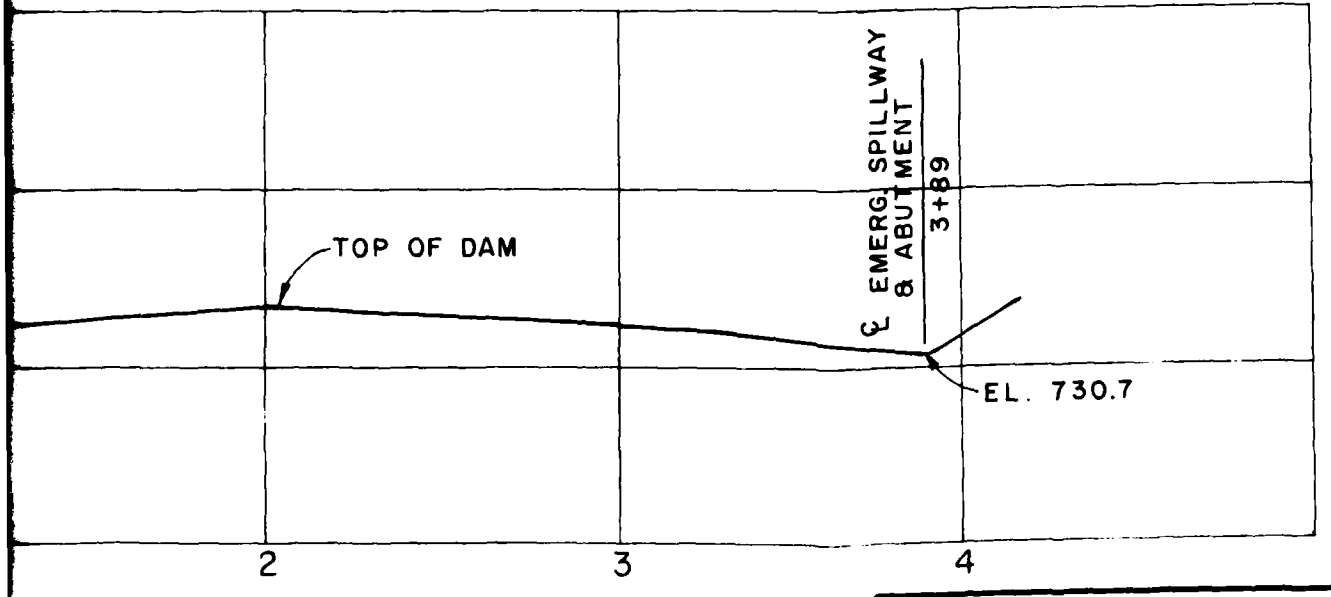
4
PHOTO LOCATION & KEY
(SEE APPENDIX A)

NOTE: LOCATION OF PHOTO NO. 6 (NOT SHOWN) BEYOND LIMITS OF PLAN VIEW



ERAL PLAN OF DAM

SCALE: 1"=50'



FILE DAM CENTERLINE

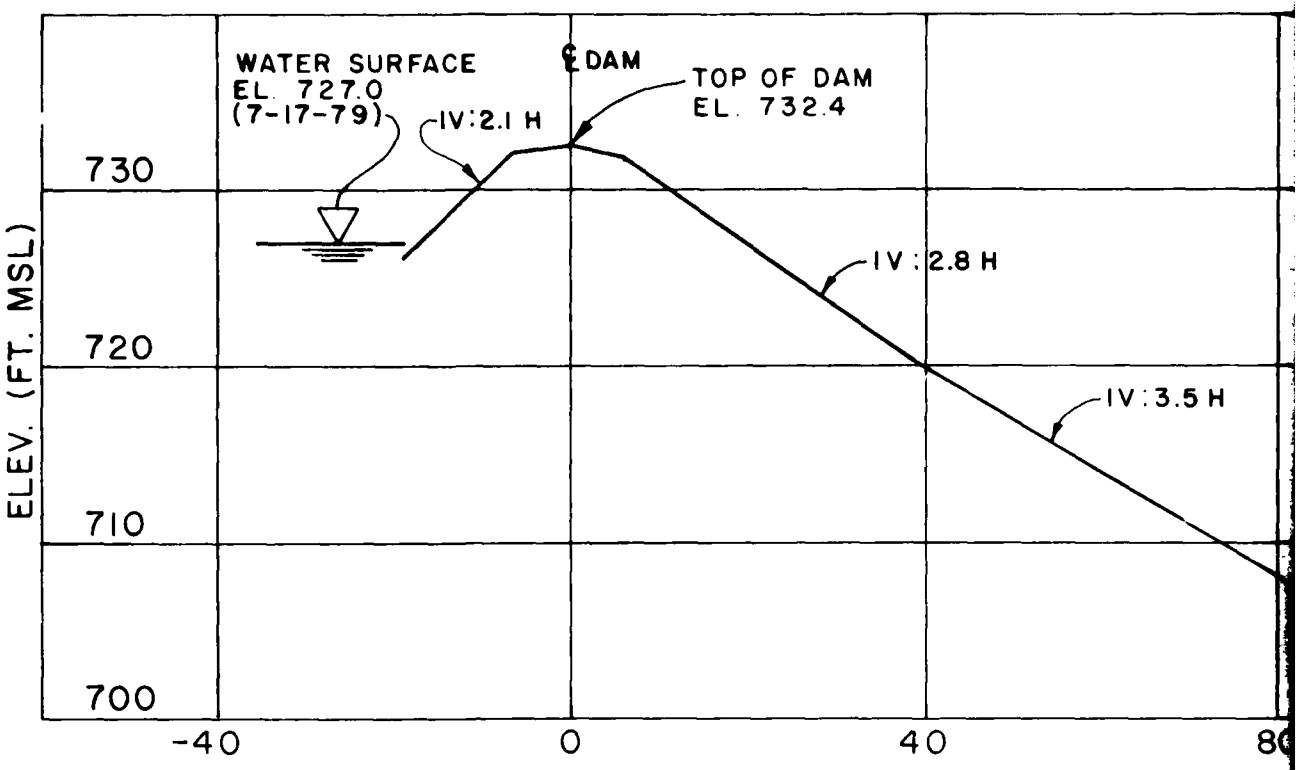
SCALES: 1"=10' V., 1"=50' H.

POWDER SPRING LAKE
DAM PLAN & PROFILE

Horner & Shifrin, Inc. Nov. 1979

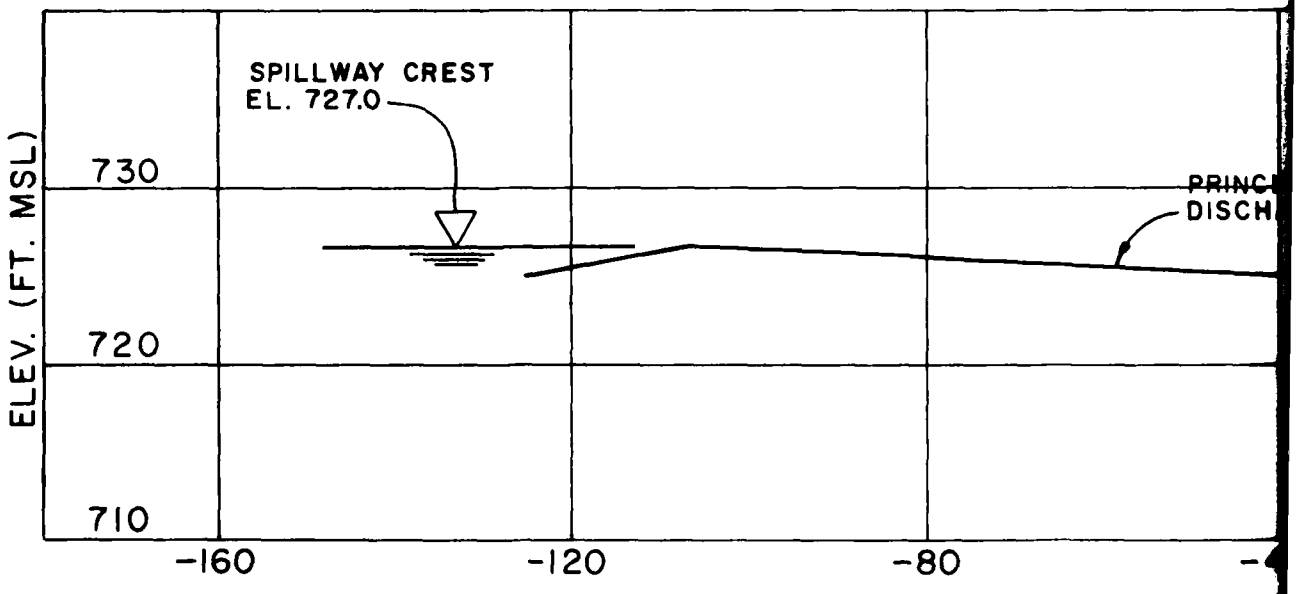
12

PLATE 3



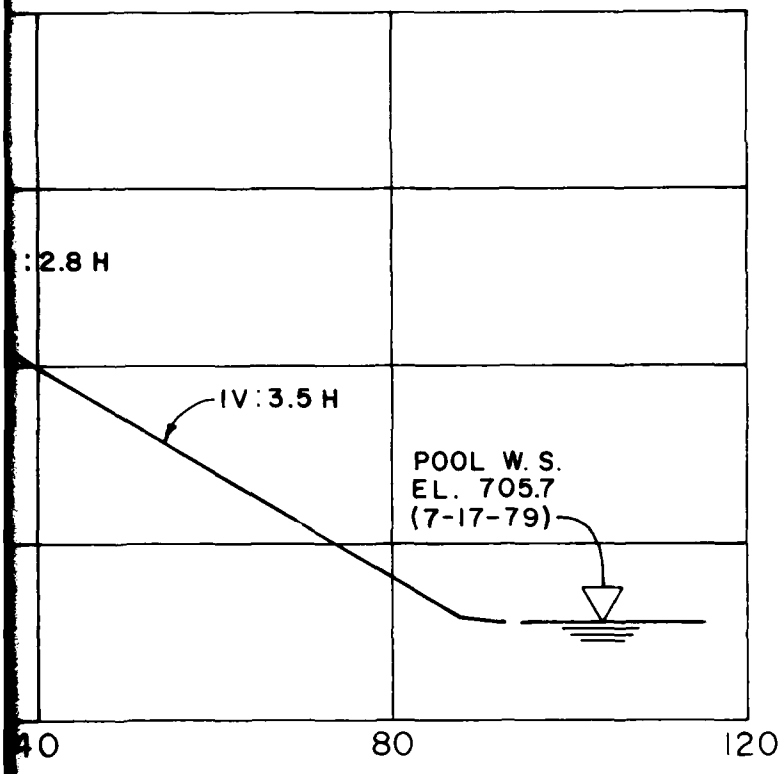
DAM CROSS SECTION STA. 3+00

SCALES: 1"=10' V., 1"=20' H.

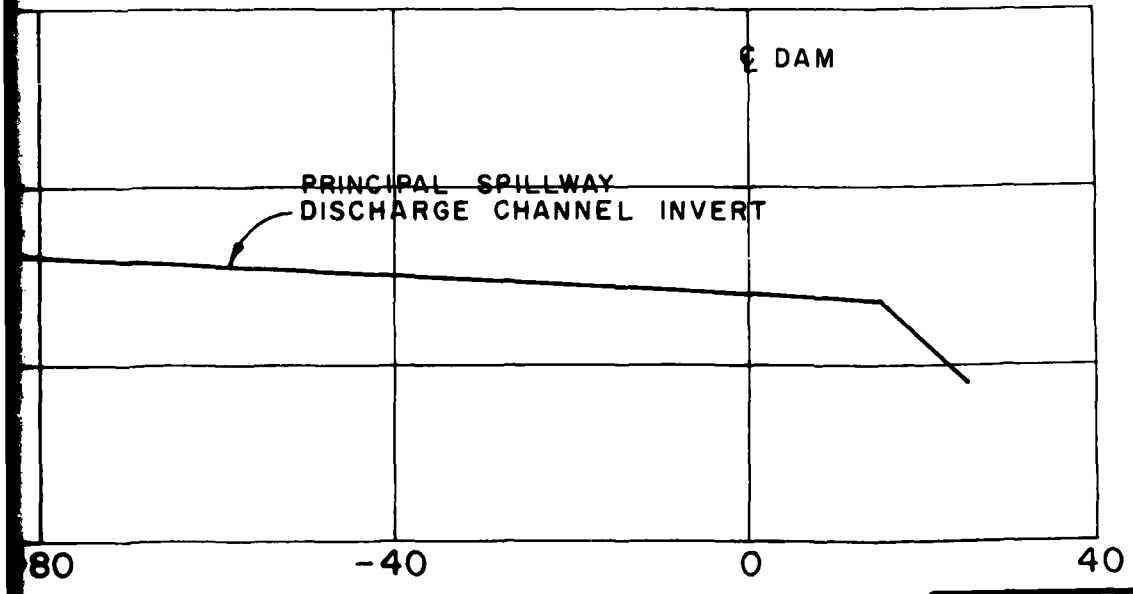


PROFILE SPILLWAY ℄

SCALES: 1"=10' V., 1"=20' H.



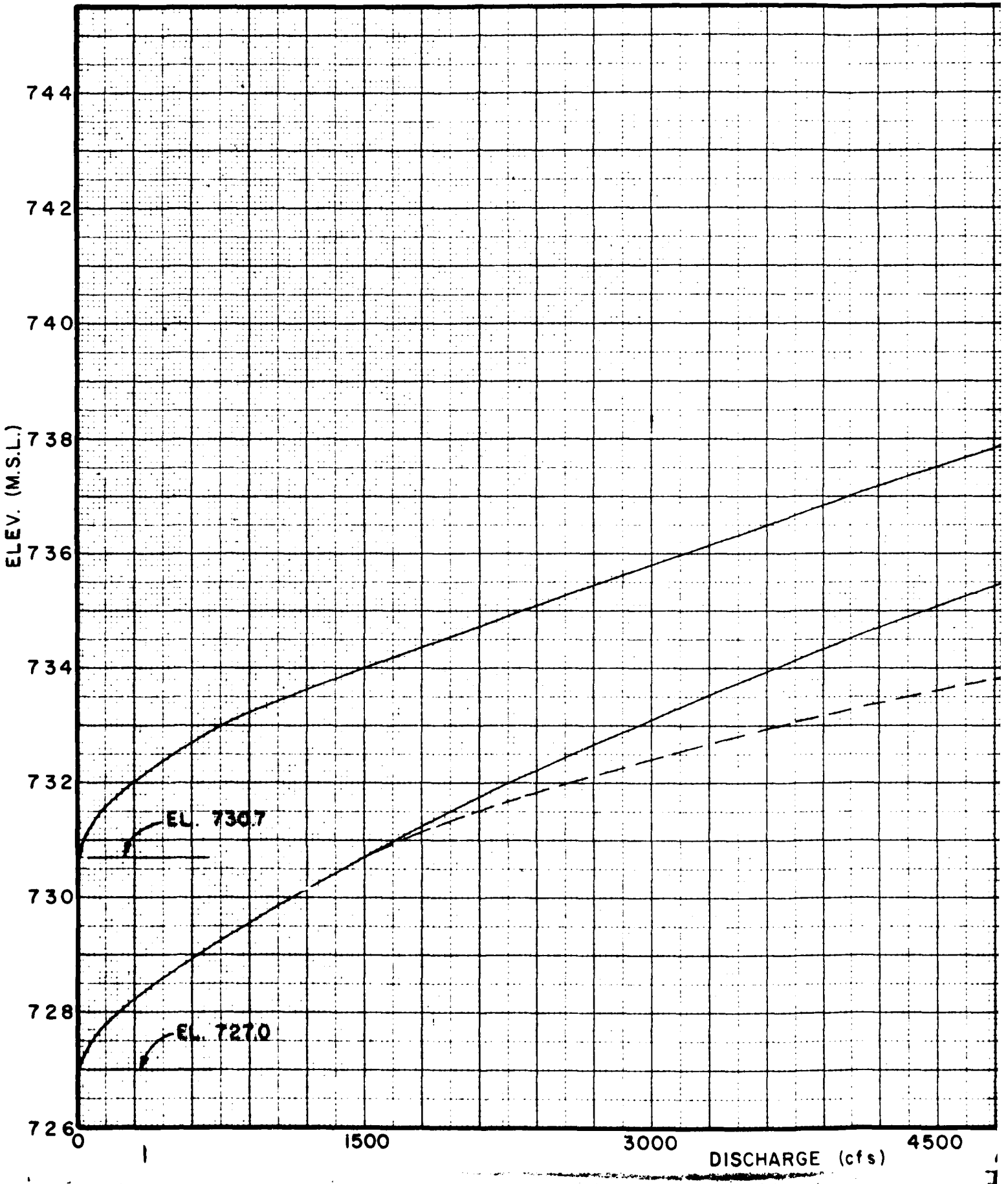
N STA. 3+00
1"=20'H.

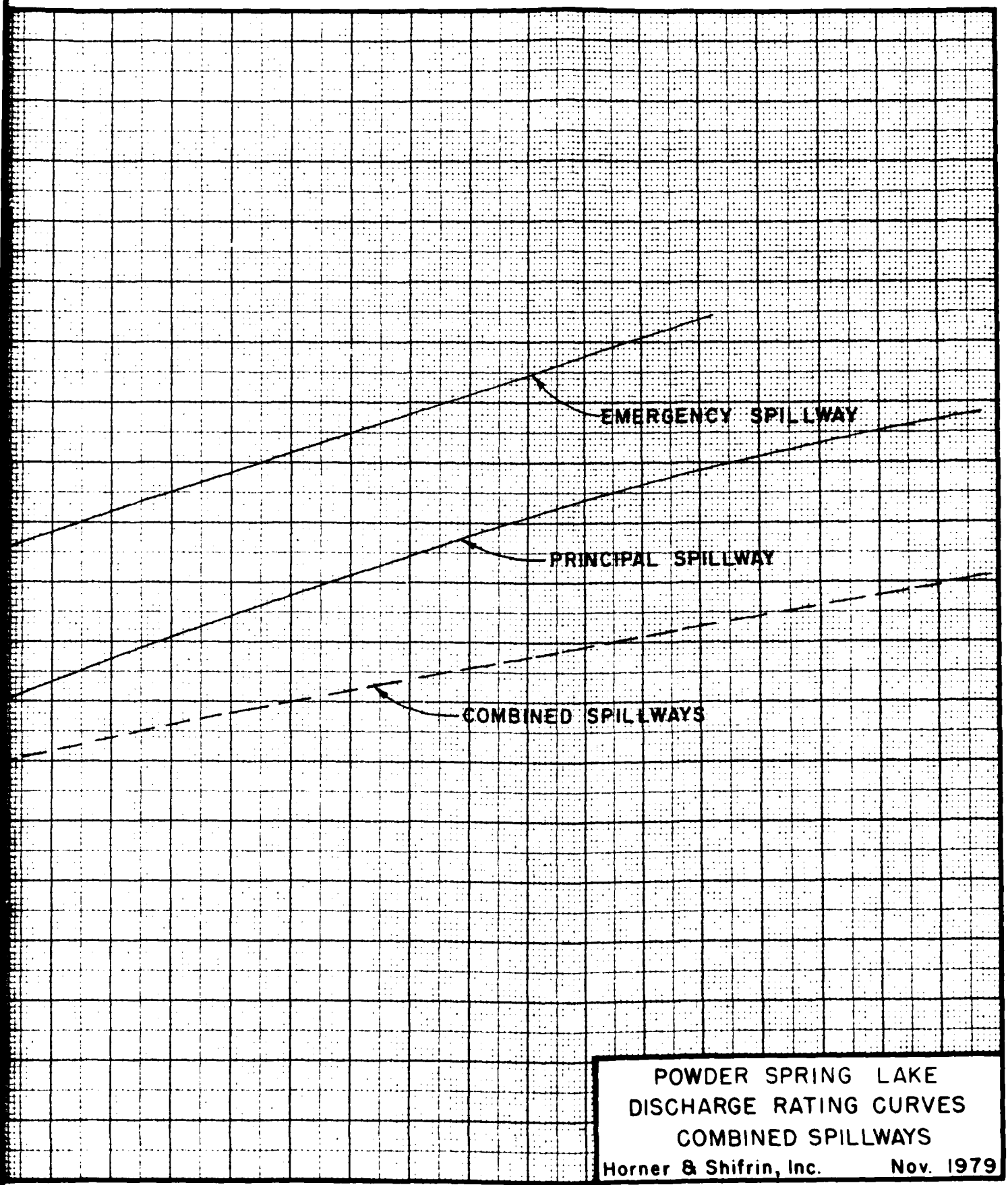


WAY ℄
=20'H.

POWDER SPRING LAKE
DAM CROSS-SECTION &
SPILLWAY PROFILE
Horner & Shifrin, Inc. Nov. 1979

PLATE 4


744
742
740
738
736
734
732
730
728
726
ELEV. (M.S.L.)
EL. 730.7
EL. 727.0
0
1500
3000
4500
DISCHARGE (cfs)

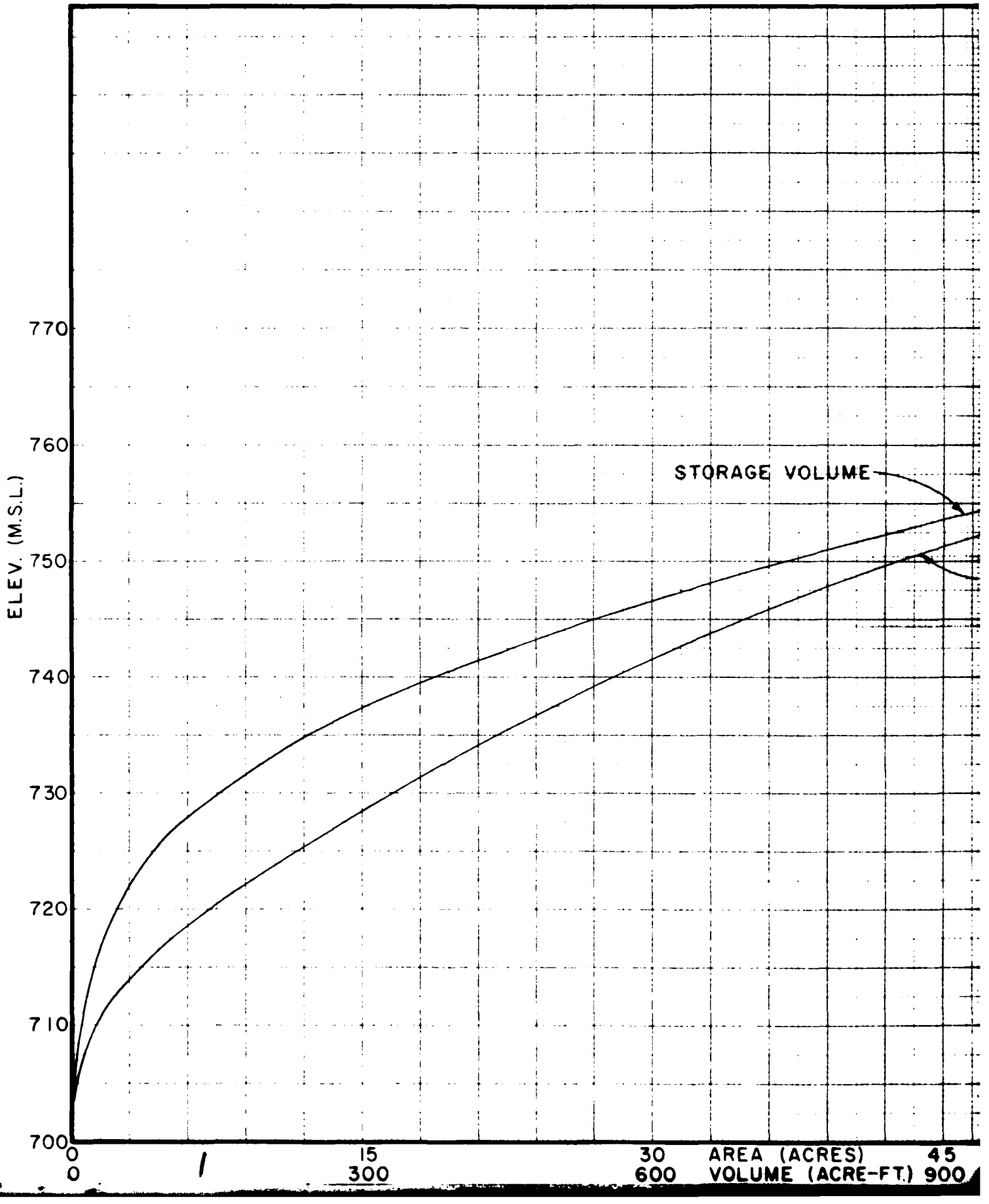


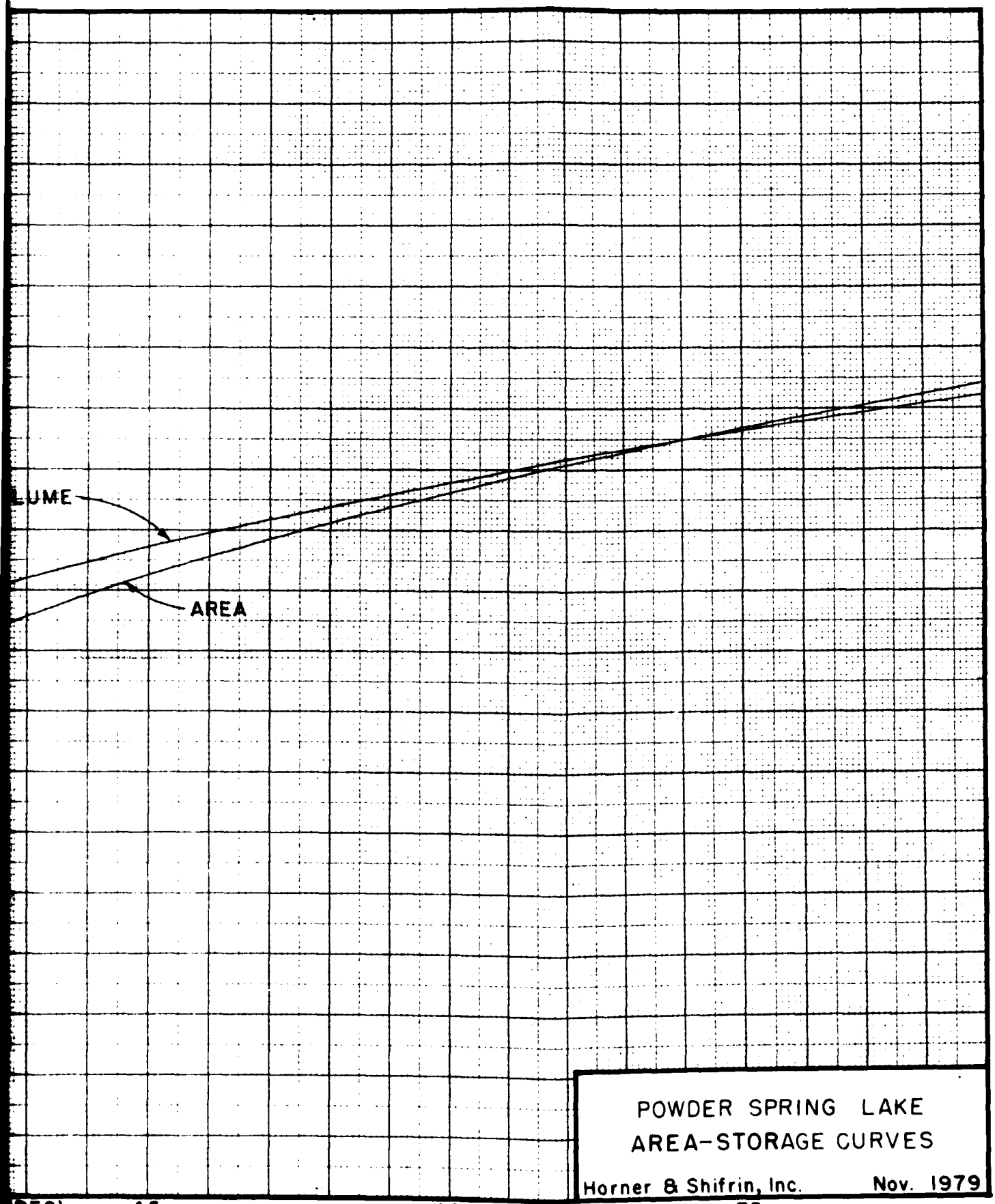
POWDER SPRING LAKE
DISCHARGE RATING CURVES
COMBINED SPILLWAYS
Horner & Shifrin, Inc. Nov. 1979

4500 6000 7500

RGE (cfs)

PLATE 5


770
760
750
740
730
720
710
700
ELEV. (M.S.L.)
STORAGE VOLUME
0
0
15
300
30
600
AREA (ACRES)
VOLUME (ACRE-FT.)
45
900



POWDER SPRING LAKE
AREA-STORAGE CURVES

Horner & Shifrin, Inc. Nov. 1979

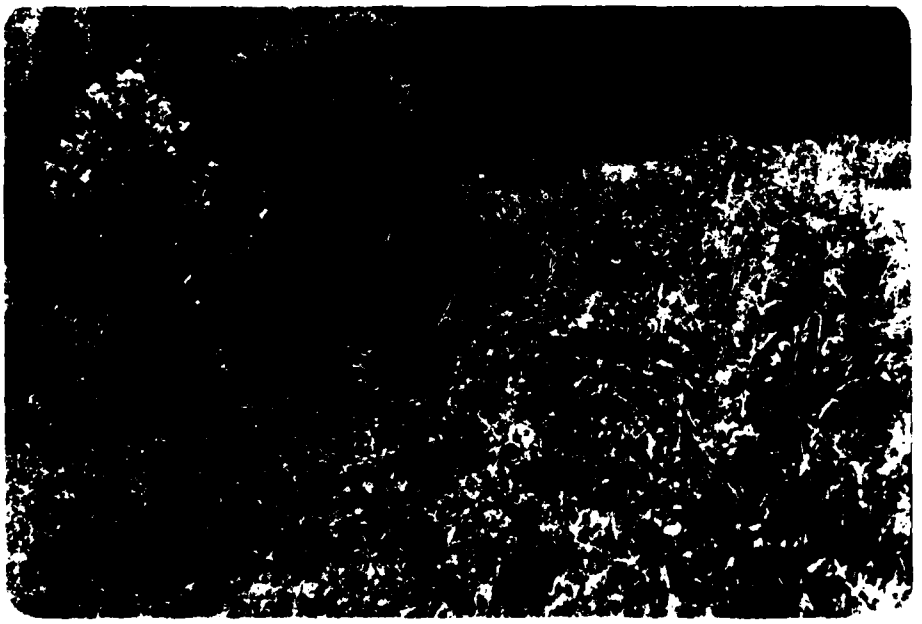
RES)
(ACRE-FT) 900

PLATE 5

APPENDIX A

INSPECTION PHOTOGRAPHS

NO. 1: UPSTREAM FACE OF DAM



NO. 2: DOWNSTREAM FACE OF DAM

NO. 3: SPILLWAY CREST

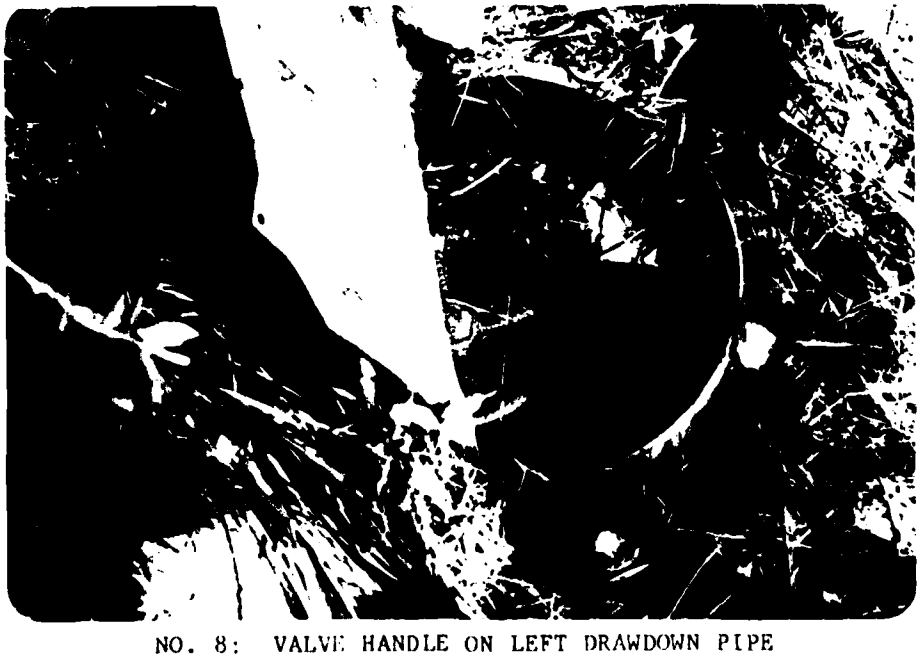
NO. 4: SPILLWAY OUTLET CHANNEL

NO. 5: ERODED BANK OF SPILLWAY CHANNEL

NO. 6: POOL AT DOWNSTREAM TOE OF DAM*

*Note location of drawdown pipes at right center of picture.

NO. 7: VALVE HANDLE ON RIGHT DRAWDOWN PIPE



NO. 8: VALVE HANDLE ON LEFT DRAWDOWN PIPE

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

1. The HEC-1 Dam Safety Version (July 1978, Modified 26 February 1979) program was used to develop inflow and outflow hydrographs and dam overtopping analyses, with hydrologic inputs as follows:

a. Probable maximum precipitation (200 sq. mile, 24-hour value equals 25.7 inches) from Hydrometeorological Report No.33. The precipitation data used in the analysis of the 1 percent (100-year frequency) flood and the 0.1 percent (10-year frequency flood) was provided by the St. Louis District, Corps of Engineers.

b. Drainage area = 4.31 square miles = 2,759 acres

c. SCS parameters (see paragraph 4 for data)

Lag time = 0.60 (Tc)

Time of Concentration (Tc) = $(\frac{11.9L^3}{H})^{0.385}$

Where: Tc = Travel time of water from hydraulically most distant point to point of interest, hours.

L = Length of longest watercourse, miles.

H = Elevation difference, feet.

2. The principal spillway consists of a broad-crested, trapezoidal section and the emergency spillway consists of a broad-crested, dish-shaped section, for which conventional weir formulas are not applicable.

Spillway release rates for these sections were determined as follows:

a. Spillway crest section properties (area, "a" and top width, "t") were computed for various depths, "d."

b. It was assumed that flow leaving the spillway control section would occur at critical depth. Flow at critical

depth was computed as $Q_c = \left(\frac{g^3}{L}\right)^{0.5}$ for the various depths, "d." Corresponding velocities (v_c) and velocity heads (H_{vc}) were determined using conventional formulas.

c. Static lake levels corresponding to the various Q_c values passing the spillway were computed as critical depths plus critical velocity heads ($d_c + H_{vc}$), and the relationship between lake level and spillway discharge was thus obtained. This procedure neglects the minor insignificant friction losses across the length of the spillway.

d. The discharges for the principal and emergency spillways for equal elevations were summated for entry on the Y4 and Y5 cards.

3. The profile of the dam crest is irregular and flow over the dam crest cannot be determined by conventional weir formulas. Crest length and elevation data for the dam crest proper were entered the HEC-1 Program on the $L and $V cards. The program computes internally the flow over the dam crest and adds this flow to the flow over the principal and emergency spillway as entered on the Y4 and Y5 cards.

4. Hydrologic data for the upstream dams and subareas are as follows:

Dam or Subarea	Area Sq. Miles	Tc Hours	(AMC III) CN	(AMC II) CN
30752	1.078	1.15	71	52
30750	0.656	1.22	75	56
30704	0.1	0.1	100	100
30707	0.1	0.1	100	100
Subarea 1	1.11	0.484	77	59
Subarea 2	1.27	0.562	77	59

Data for Dams 30752, 30750, 30704 and 30707 were obtained from Phase I Dam Safety Inspection Reports by International Engineering Co., Inc. For elevation-area relationships, see computer program input data.

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A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF POWDER SPRINGS LAKE DAM
A3       RATIOS OF PMF ROUTED THROUGH RESERVOIR
B     258          0         5                                                  4
B1      5
J       1          4         1
J1    .01       .05       .10       .15
K       0  RUNOFF                                                        1
K1         INFLOW TO LAKE 30752
M       1          2     1.078                                  1.0
P       0       25.8       102       120       130
T                                                                -1       -71                .029
W2             1.15
X     -10       -.1       2.5
K       1  30752
K1       PMF RATIOS ROUTED THROUGH LAKE 30752
Y                                        1         1
Y1      1                                                      -845        -1
Y4  844.9     845.0     845.5     846.0     846.5     847.0     847.5     848.0     848.5     849.0
Y5      0        11        26        38        43       126       491      1238      2405      4374
SA      0       6.7       9.3      12.5      14.0      15.4      16.2      17.2      20.0      22.5
SA   25.8
SE    840       841       842       844       845       846     846.5       847       848       849
SE    850
SS  846.5
SD  846.5
K       0  RUNOFF                                                        1
K1         INFLOW TO LAKE 30750
M       1          2      .656                                  1.0
P       0       25.8       102       120       130
T                                                                -1       -75                .131
W2             1.22
X     -10       -.1       2.5
K       2  UP+LOW                                                        1
K1       COMB OF OUTFLOW FROM 30752 AND RUNOFF TO 30750
K       1  30750                                                         1
K1       PMF RATIOS  ROUTED THROUGH RESERVOIR-30750
Y                                        1         1
Y1      1                                                      -842.3        -1
Y4  842.3     843.0     843.5     844.0     845.0     845.5     846.0     847.1     848.0     849.0
Y5      0        66       182       345       809      1110      1920      2700      3873      6510
SA     33        49        54        58        62        64        66        68        70        72
SE    842       843       844       845       846     846.5       847       848       849       850
SS  842.3
SD  847.1
```

```
K         0  RUNOFF                                                                  1
K1          PMF RATIOS INFLOW TO LAKE 30704
M         1         2        .1                                          1.0
P         0      25.8       102       120       130
T                                                                                  -1      -100
W2                  .1
X     -.01      -.01       1.0
K         1  LAKE                                                                   1
K1          RESERVOIR ROUTING THROUGH 30704
Y                                       1         1
Y1        1                                                                        -903.5      -1
Y4    900.0     907.5     907.7     908.1     908.6     909.2     909.7     910.3
Y5        0     0.001        10       218       872      2503      4823      6408
SA        0        10        17      27.5        34        42        60
SE      900     903.3       905       907       908       909       911
$$  907.5
$D  907.5
K         1REACH A                                                                 1
K1        STREAM ROUTING - REACH A
Y                                       1         1
Y1        1
Y5    0.045     0.030     0.045       796       910      4962     0.031
Y7        0       822        40       802       120       801       130       796       135       796
Y7      145       801       220       802       240       822
K         2CULVHY E                                                   1             1
K1          INFLOW TO CULVERT AT HWY E
K         1 REACH B                                                                1
K1          ROUTING THROUGH STREAM REACH B
Y                                               1
Y1        1
Y6    0.060     0.035     0.048       754       810      3700     0.012
Y7        0       740        40       756        58       755        60       754        75       754
Y7       85       759       390       760       640       780
K         0  RUNOFF                                                                1             1
K1          PMF RATIOS INFLOW TO 30707
M         1         2        .1                                          1.0
P         0      25.8       102       120       130
T                                                                                  -1      -100
W2                  .1
X     -.01      -.01       1.0
K         1  LAKE                                                                   1
K1          RESERVOIR ROUTING THROUGH 30707
Y                                       1         1
Y1        1                                                                        -860.8      -1
Y4    861.0     861.5     862.0     862.5     863.0     863.5     864.0
Y5        0       140       510      1360      3000      5000      7600
SA        0       4.6      26.3      27.5      30.5      33.7      36.9      40.0      43.0      46.3
SE      856       860     860.8       861     861.5       862     862.5       863     863.5       864
$$861.00
$D  861.0
```

```
K        1REACH  C                                                    1
K1        STREAM ROUTING THROUGH REACH C
Y                                                  1
Y1        1
Y6  0.050    0.050    0.050      860       755      2500     0.038
Y7        0      750      250      757       260       755       270       757       340       760
Y7      520      770      700      780       900       790
K        2COMB STM                                    1         1
K1        COMB STREAM FLOWS B&C
K        1REACH  D                                    1         1
K1        STREAM ROUTING THROUGH REACH D
Y                                                  1
Y1        1
Y5  0.038    0.035    0.038      727       770      2500     0.011
Y7        0      760      100      740       182       736       200       727       215       727
Y7      233      736      320      740       550       760
K        0  RUNOFF                                            1
K1        PMF RATIOS INFLOW FROM SUBAREA 1
M         1        2     1.11                          1.0
P         0     25.8      102      120       130
T                                                              -1       -77                 0.04
W2              0.464
X    -1.0      -.10       2.0
K        0  RUNOFF                                            1
K1        PMF RATIOS INFLOW FROM SUBAREA 2
M         1        2     1.27                          1.0
P         0     25.8      102      120       130
T                                                              -1       -77
W2              0.562
X    -1.0      -.10       2.0
K        3COMB                                             1
K1        COMBINATION OF HYDROGRAPHS FOR SUBAREA 1,2,AND CHANNEL D
K        1DAM    PS                                        1
K1        POWDER SPRINGS DAM-RESERVOIR ROUTING BY MODIFIED PULS
Y                                  1         1
Y1        1                                                106.3       -1
Y4      727    727.5    728.0    728.5     729.0     729.5     730.0     730.7     731.0     731.3
Y4  732.0    733.0    734.0    735.0     736.0     737.0     738.0     739.0     740.0
Y5        0       60      210      410       630       860      1120      1490      1690      1920
Y5     2550     3660     5110     6750      8450     10260     12300     14720     17260
$A        0     13.5     27.9     62.4
$E703.27       727      740      760
$$      727
$D  731.3
$L        0      102      113      163       333
$V  731.3      732    732.1    732.4     733.4
K        99
```

```
A1       ANALYSIS OF OVERTOPPING USING RATIOS OF PMF
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF POWDER SPRINGS LAKE DAM
A3       RATIOS OF PMF ROUTED THROUGH RESERVOIR
B     288          0         5                                                  4
B1      5
J       1         2         1
J1    .50       1.0
K         0  RUNOFF                                                  1
K1         INFLOW TO LAKE 30752
M       1         2     1.078                          1.0
P       0      25.8       102       120       130
T                                                     -1       -71              .029
W2              1.15
X     -10        -.1       2.5
K         0  RUNOFF                                                  1
K1         INFLOW TO LAKE 30750
M       1         2      .656                          1.0
P       0      25.8       102       120       130
T                                                     -1       -75              .131
W2              1.22
X     -10        -.1       2.5
K         2  UP+LOW                                                  1
K1         COMB OF OUTFLOW FROM 30752 AND RUNOFF TO 30750
K       1    30750                                                  1
K1         PMF RATIOS  ROUTED THROUGH RESERVOIR-30750
Y                                    1         1
Y1      1                                                -842.3       -1
Y4  842.3     843.0     843.5     844.0     845.0     845.5      846.0     847.1     848.0     849.0
Y5        0        56       182       345       809      1110       1520      2700      3973      6510
$A       33        49        54        58        62        64         66        68        70        72
$E      842       843       844       845       846     846.5        847       848       849       850
$$  842.3
$D  847.1
K         0  RUNOFF                                                  1
K1         PMF RATIOS INFLOW TO LAKE 30704
M       1         2        .1                          1.0
P       0      25.8       102       120       130
T                                                     -1      -100
W2              .1
X     -.01      -.01       1.0
K         1  LAKE                                                    1
K1         RESERVOIR ROUTING THROUGH 30704
Y                                    1         1
Y1      1                                                -903.5       -1
Y4  900.0     907.5     907.7     908.1     908.6     909.2      909.7     910.3
Y5        0     0.001        10       218       872      2503       4823      7606
$A        0        10        17        27        34        42         60
$E      900       903       905       907       908       909        911
$$  907.5
$D  907.5
```

```
K       1REACH A                                                        1
K1      STREAM ROUTING - REACH A
Y                                       1       1
Y1      1
Y6  0.045    0.030    0.045     796     910    4962    0.031
Y7      0      822       40     802     120     801      130     796     135     796
Y7    145      801      220     802     260     822
K       2CULVHY E                                       1       1
K1       INFLOW TO CULVERT AT HWY E
K       1 REACH B                                               1
K1       ROUTING THROUGH STREAM REACH B
Y                                       1
Y1      1
Y6  0.060    0.035    0.048     754     810    3700    0.012
Y7      0      780       40     756      58     755       60     754      75     754
Y7     85      759      390     760     640     780
K       0  RUNOFF                                       1       1
K1          PMF RATIOS INFLOW TO 30707
M       1       2       .1                              1.0
P       0     25.8      102     120     130
T                                                               -1    -100
W2                    .1
K    -.01     -.01      1.0
K       1    LAKE                                               1
K1       RESERVOIR ROUTING THROUGH 30707
Y                                       1       1
Y1      1                                               -860.8      -1
Y4  861.0    861.5    862.0   862.5    863.0   863.5    864.0
Y5      0      140      510    1360     3000    5000     7600
$A      0      4.6     26.3    27.5     30.5    33.7     36.9    40.0    43.0    46.3
$E    855      860    860.8     861    861.5     862    862.5     863    863.5     864
$$861.00
$0  861.0
K       1REACH C                                                1
K1       STREAM ROUTING THROUGH REACH C
Y                                       1
Y1      1
Y6  0.050    0.050    0.050     860     755    2500    0.038
Y7      0      760      250     757     260     755      270     757     340     760
Y7    520      770      700     780     900     790
K       2COMB STM                                       1       1
K1       COMB STREAM FLOWS B&C
K       1REACH  D                               1               1
K1       STREAM ROUTING THROUGH REACH D
Y                                       1
Y1      1
Y6  0.038    0.035    0.038     727     770    2500    0.011
Y7      0      760      100     740     182     736      200     727     215     727
Y7    233      736      320     740     550     760
```

```
K         0  RUNOFF                                                    1
K1        PMF RATIOS INFLOW FROM SUBAREA 1
M         1         2      1.11                              1.0
P         0      25.8       102       120       130
T                                                                  -1      -77                 0.04
W2                0.484
X      -1.0       -.10       2.0
K         0  RUNOFF                                                    1
K1        PMF RATIOS INFLOW FROM SUBAREA 2
M         1         2      1.27                              1.0
P         0      25.8       102       120       130
T                                                                  -1      -77
W2                0.562
X      -1.0       -.10       2.0
K         3COMB                                                     1
K1        COMBINATION OF HYDROGRAPHS FOR SUBAREA 1,2,AND CHANNEL D
K         1DAM    PS                                2               1
K1        POWDER SPRINGS DAM-RESERVOIR ROUTING BY MODIFIED PULS
Y                                   1         1                 106.8      -1
Y1        1
Y4      727     727.5     728.0     728.5     729.0     729.5     730.0     730.7     731.0     731.3
Y4    732.0     733.0     734.0     735.0     736.0     737.0     738.0     739.0     740.0
Y5        0        50       210       510       930      1460      1130      1480      1850      1991
Y5     2550      3660      5110      6750      8450     10260     12300     14720     17260
$A        0      13.5      27.9      62.4
$E   703.27       727       740       760
$$      727
$D    731.3
$L        0       102       113       163       333
$V    731.3       732     732.1     732.4     733.4
K        99
```

```
A1       ANALYSIS OF DAM OVERTOPPING USING 100YR FLOOD
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF POWDER SPRINGS LAKE DAM
A3       100YR FLOOD ROUTED THROUGH RESERVOIR
B      288       0       5                                                      4
B1       5
J        1       1       1
J1     1.0     .20
K        0   RUNOFF                                           1
K1           INFLOW TO LAKE 30752
M        0       2   1.076                          1.0
O      288
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .013    .013    .013    .013    .013    .013    .013    .013
O1    .013    .013    .013    .013    .013    .013    .013    .013    .013    .013
O1    .013    .013    .013    .013    .013    .013    .013    .013    .013    .013
O1    .013    .013    .013    .013    .013    .013    .013    .013    .013    .013
O1    .013    .013    .013    .013    .013    .013    .013    .013    .013    .013
O1    .013    .013    .013    .013    .013    .013    .013    .013    .013    .013
O1    .013    .013    .013    .013    .013    .013    .013    .013    .013    .013
O1    .013    .013    .013    .013    .024    .024    .024    .024    .024    .024
O1    .024    .024    .024    .024    .024    .024    .024    .024    .024    .024
O1    .024    .024    .031    .031    .031    .031    .031    .031    .049    .049
O1    .049    .049    .049    .049    .138    .138    .139    .262    .262    .544
O1    .813    .379    .262    .139    .138    .138    .049    .049    .049    .049
O1    .049    .049    .031    .031    .031    .031    .031    .031    .024    .024
O1    .024    .024    .024    .024    .024    .024    .024    .024    .024    .024
O1    .024    .024    .024    .024    .024    .024    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007
T                                                       -1     -52            .029
W2            1.15
X      -10     -.1     2.5
K        1   30752
K1       PMF RATIOS ROUTED THROUGH LAKE 30752
Y                                1       1
Y1       1                                                    -845      -1
Y4   844.9   845.0   845.5   846.0   846.5   847.0   847.5   848.0   848.5   849.0
Y5       0      11      26      36      43     126     491    1238    2495    4376
$A       0     6.7     9.3    12.5    14.0    15.4    16.2    17.2    20.0    22.5
$A    25.9
$E     840     841     842     844     845     846   846.5     847     848     849
$E     850
$$   846.5
$D   846.5
```

```
K        0  RUNOFF                                                    1
K1          INFLOW TO LAKE 30750
M        0         2      .054                        1.0
O    -288
T                                                                   -1      -.4                  .131
W2              1.22
X      -10       -.1       2.5
K        2  UP+LOW                                                   1
K1        COMB OF OUTFLOW FROM 30752 AND RUNOFF TO 30750
K        1  30750                                                    1
K1        PMF RATIOS  ROUTED THROUGH RESERVOIR-30750
Y                                  1         1
Y1       1                                                  -842.3       -1
Y4   842.3     843.0     843.5     844.0     845.0     845.5     846.0     847.1     848.0     849.0
Y5       0        66       182       345       809      1110      1520      2700      3873      6510
$A      33        49        54        58        62        64        66        68        70        72
$E     842       843       844       845       846      846.5      847       848       849       950
$$  842.3
$D  847.1
K        0  RUNOFF                                                    1
K1        PMF RATIOS INFLOW TO LAKE 30704
M        0         2        .1                        1.0
O    -288
T                                                                   -1     -100
W2              .1
X     -.01      -.01       1.0
K        1  LAKE                                                     1
K1        RESERVOIR ROUTING THROUGH 30704
Y                                  1         1
Y1       1                                                  -903.5       -1
Y4   900.0     907.5     907.7     908.1     908.6     909.2     909.7     910.3
Y5       0     0.001        10       218       872      2503      4823      8408
$A       0        10        17      27.5        34        42        66
$E     900       903       905       907       908       909       911
$$  907.5
$D  907.5
K        1REACH A                                                    1
K1        STREAM ROUTING - REACH A
Y                                  1         1
Y1       1
Y6   0.045     0.030     0.045       796       910      4962     0.031
Y7       0       822        40       802       120       801       130       796       135       796
Y7     145       801       220       802       260       822
K        2CULVHY E                                          1        1
K1        INFLOW TO CULVERT AT HWY E
K        1 REACH B                                                   1
K1        ROUTING THROUGH STREAM REACH B
Y                                              1
Y1       1
Y6   0.060     0.035     0.048       754       810      3700     0.012
Y7       0       780        40       756        58       755        60       754        75       754
Y7      85       759       390       760       640       780
K        0  RUNOFF                                             1        1
K1        PMF RATIOS INFLOW TO 30707
M        0         2        .1                        1.0
O    -288
T                                                                   -1     -100
W2              .1
X     -.01      -.01       1.0
```

```
K        1      LAKE                                                    1
K1        RESERVOIR ROUTING THROUGH 30707
Y                                        1         1
Y1        1                                                  -860.8       -1
Y4  861.0    861.5    862.0    862.5    863.0    863.5    864.0
Y5        0      140      510     1360     3000     5000     7600
$A        0      4.6     26.3     27.5     30.5     33.7     36.9      40.0      43.0      46.3
$E      856      860    860.8      861    861.5      862    862.5       863    863.5       864
$$861.00
$D 861.8
K        1REACH  C                                                       1
K1        STREAM ROUTING THROUGH REACH C
Y                                                 1
Y1        1
Y5 0.050    0.050    0.050      860      755     2500    0.038
Y7        0      730      250      757      260      755      270       757       340       760
Y7      520      770      700      780      900      790
K         2COMB STM                                          1         1
K1        COMB STREAM FLOWS B&C
K         1REACH  D                                    1                1
K1        STREAM ROUTING THROUGH REACH D
Y                                                 1
Y1        1
Y5 0.035    0.035    0.038      727      770     2500    0.011
Y7        0      760      100      740      182      736      200       727       215       727
Y7      233      736      320      740      550      760
K         0  RUNOFF                                                     1
K1        PMF RATIOS INFLOW FROM SUBAREA   1
M         0        2     1.11                        1.0
O    -288
T                                                                -1       -59                 0.04
W2                0.484
X    -1.0      -.10      2.0
K         0  RUNOFF                                                     1
K1        PMF RATIOS INFLOW FROM SUBAREA  2
M         0        2     1.27                        1.0
O    -238
T                                                                -1       -59
W2                0.562
X    -1.0      -.10      2.0
K         3COMB                                                      1
K1        COMBINATION OF HYDROGRAPHS FOR SUBAREA 1,2,AND CHANNEL D
K         1DAM     PS                                                1
K1        POWDER SPRINGS DAM-RESERVOIR ROUTING BY MODIFIED PULS
Y                                        1         1
Y1        1                                                   106.8       -1
Y4   727    727.5    728.0    728.5    729.0    729.5    730.0     730.7     731.0     731.3
Y4 732.0    733.0    734.0    735.0    736.0    737.0    738.0     739.0     740.0
Y5        0       60      210      410      630      860     1120      1490      1690      1920
Y5   2550     3660     5110     6750     8450    10260    12300     14720     17260
$A        0     13.5     27.9     62.4
$E703.27      727      740      760
$$    727
$D 731.3
$L        0      102      113      163      333
$V 731.3      732    732.1    732.4    733.4
K        99
```

```
A1       ANALYSIS OF DAM OVERTOPPING USING 10 YR FLOOD
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF POWDER SPRINGS LAKE DAM
A3       10 YR FLOOD ROUTED THROUGH RESERVOIR
B     288          0          5                                                  4
B1      5
J       1          1          1
J1    1.0        .20
K         0  RUNOFF                                                 1
K1         INFLOW TO LAKE 30752
M         0          2      1.07                          1.0
O     288
O1    .005       .005       .005       .005       .005       .005       .005       .005       .005       .005
O1    .005       .005       .005       .005       .005       .005       .005       .005       .005       .005
O1    .005       .005       .005       .005       .005       .005       .005       .005       .005       .005
O1    .005       .005       .005       .005       .005       .005       .005       .005       .005       .005
O1    .005       .005       .005       .005       .005       .005       .005       .005       .005       .005
O1    .005       .005       .005       .005       .005       .005       .005       .005       .005       .005
O1    .005       .005       .010       .010       .010       .010       .010       .010       .010       .010
O1    .010       .010       .010       .010       .010       .010       .010       .010       .010       .010
O1    .010       .010       .010       .010       .010       .010       .010       .010       .010       .010
O1    .010       .010       .010       .010       .010       .010       .010       .010       .010       .010
O1    .010       .010       .010       .010       .010       .010       .010       .010       .010       .010
O1    .010       .010       .010       .010       .010       .010       .010       .010       .010       .010
O1    .010       .010       .010       .010       .015       .015       .015       .015       .015       .015
O1    .015       .015       .015       .015       .015       .015       .015       .015       .040       .040
O1    .040       .040       .040       .040       .091       .091       .091       .172       .172       .377
O1    .580       .262       .172       .091       .091       .091       .040       .040       .040       .040
O1    .040       .040       .027       .027       .027       .027       .027       .027       .015       .015
O1    .015       .015       .015       .015       .015       .015       .015       .015       .015       .015
O1    .015       .015       .015       .015       .015       .015       .005       .005       .005       .005
O1    .005       .005       .005       .005       .005       .005       .005       .005       .005       .005
O1    .005       .005       .005       .005       .005       .005       .005       .005       .005       .005
O1    .005       .005       .005       .005       .005       .005       .005       .005       .005       .005
O1    .005       .005       .005       .005       .005       .005       .005       .005       .005       .005
O1    .005       .005       .005       .005       .005       .005       .005       .005       .005       .005
O1    .005       .005       .005       .005       .005       .005       .005       .005
T                                                                        -1         -52                    .029
W2               1.15
X       -10        -.1        2.5
K         1    30752
K1          PMF RATIOS ROUTED THROUGH LAKE 30752
Y                                        1          1
Y1        1                                                    -846                -1
Y6    844.9      845.0      845.5      846.0      846.5      847.0      847.5      848.0      848.5      849.0
Y5        0         11         26         36         43        126        491       1238       2405       4376
SA        0        6.7        9.3       12.5       14.0       15.4       16.2       17.2       20.0       22.5
SA     25.8
SF      840        841        842        844        845        845      846.5        847        848        849
SF      850
SS    846.5
SD    846.5
```

```
K         0  RUNOFF                                                    1
K1           INFLOW TO LAKE 30750
M         0         2     .656                          1.0
O    -288
T                                                                   -1      -56                .131
W2              1.22
X     -10        -.1      2.5
K         2  UP+LOW                                                  1
K1           COMB OF OUTFLOW FROM 30752 AND RUNOFF TO 30750
K         1  30750                                                   1
K1           PMF RATIOS  ROUTED THROUGH RESERVOIR-30750
Y                                    1         1
Y1        1                                                 -842.3      -1
Y4  842.3     843.0     843.5     844.0     845.0     845.5     846.0   847.1     848.0     849.0
Y5        0        66       182       345       809      1110      1520    2700      3873      6510
$A       33        49        54        58        62        64        66      68        70        72
$E      842       843       844       845       846     846.5       847     848       849       850
$$  842.3
$D  847.1
K         0  RUNOFF                                                    1
K1           PMF RATIOS INFLOW TO LAKE 30704
M         0         2       .1                          1.0
O    -288
T                                                                   -1      -100
W2              .1
X     -.01       -.01      1.0
K         1  LAKE                                                     1
K1           RESERVOIR ROUTING THROUGH 30704
Y                                    1         1
Y1        1                                                 -903.5      -1
Y4  900.0     907.5     907.7     908.1     908.6     909.2     909.7   910.3
Y5        0     0.001        10        21.8       872      2503      4823    8605
$A        0        10        17        27.5       34        42        66
$E      900       903.3     905       907       908       909       911
$$  907.5
$D  907.5
K         1REACH A                                                  1
K1           STREAM ROUTING - REACH A
Y                                    1         1
Y1        1
Y6  0.045     0.030     0.045       796       910      4962     0.031
Y7        0       822        40       802       120       801       130      796       135       796
Y7      145       801       220       802       260       822
K         2CULVHY E                                                 1
K1           INFLOW TO CULVERT AT HWY E
K         1 REACH B                                                 1
K1           ROUTING THROUGH STREAM REACH B
Y                                    1
Y1        1
Y6  0.060     0.035     0.048       754       810      3700     0.012
Y7        0       780        40       756        58       755        60      754        75      754
Y7       95       759       390       760       640       780
K         0  RUNOFF                                                    1
K1           PMF RATIOS INFLOW TO 30707
M         0         2       .1                          1.0
O    -289
T                                                                   -1      -100
W2              .1
X     -.01       -.01      1.0
```

```
K         1     LAKE                                                    1
K1         RESERVOIR ROUTING THROUGH 30707
Y                                      1         1
Y1        1                                                -860.8       -1
Y4 861.0     861.5     862.0     862.5     863.0     863.5     864.0
Y5        0       140       510      1360      3000      5000      7600
$A        0       4.6      26.2      27.5      30.5      33.7      36.9      40.0      43.0      46.3
$E      856       860     860.8       861     861.5       862     862.5       863     863.5       864
$$861.00
$D 861.0
K         1REACH  C                                                     1
K1         STREAM ROUTING THROUGH REACH C
Y                                          1
Y1        1
Y6 0.050     0.050     0.050       860       755      2500     0.038
Y7        0       780       250       757       260       755       270       757       340       760
Y7      520       770       700       780       900       790
K          2COMB STM                                          1         1
K1         COMB STREAM FLOWS B&C
K         1REACH  D                                    1                1
K1         STREAM ROUTING THROUGH REACH D
Y                                          1
Y1        1
Y6 0.038     0.035     0.038       727       770      2500     0.011
Y7        0       760       100       740       182       736       200       727       215       727
Y7      233       736       320       740       550       760
K         0  RUNOFF                                                    1
K1         PMF RATIOS INFLOW FROM SUBAREA   1
M         0         2     1.11                                  1.0
O      -288
T                                                               -1       -59                 0.04
W2                0.484
X      -1.0       -.10      2.0
K         0  RUNOFF                                                    1
K1         PMF RATIOS INFLOW FROM SUBAREA  2
M         0         2     1.27                                  1.0
O      -288
T                                                               -1       -59
W2                0.562
X      -1.0       -.10      2.0
K          3COMB                                                    1
K1         COMBINATION OF HYDROGRAPHS FOR SUBAREA 1,2,AND CHANNEL D
K          1DAM     PS                                                1
K1         POWDER SPRINGS DAM-RESERVOIR ROUTING BY MODIFIED PULS
Y                                          1         1
Y1        1                                                 106.8       -1
Y4    727     727.5     728.0     728.5     729.0     729.5     730.0     730.7     731.0     731.3
Y4  732.0     733.0     734.0     735.0     736.0     737.0     738.0     739.0     740.0
Y5        0        60       210       410       630       960      1120      1490      1690      1920
Y5     2550      3660      5110      6750      8450     10260     12300     14720     17260
$A        0      13.5      27.9      62.4
$E703.27       727       740       760
$$    727
$D 731.3
$L        0       102       113       163       333
$V 731.3       732     732.1     732.4     733.4
K        99
```

SUMMARY OF DAM SAFETY ANALYSIS
RATIOS OF PMF

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	727.00	727.00	731.30
STORAGE	107.	107.	174.
OUTFLOW	0.	0.	1920.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.01	727.73	0.00	117.	129.	0.00	16.50	0.00
.05	729.19	0.00	139.	717.	0.00	16.42	0.00
.10	730.72	0.00	164.	1503.	0.00	16.42	0.00
.15	731.92	.62	185.	2526.	.83	16.33	0.00
.50	734.79	3.49	242.	10313.	6.67	16.17	0.00
1.00	737.23	5.93	298.	21722.	8.42	16.17	0.00

SUMMARY OF DAM SAFETY ANALYSIS
100-YR. FLOOD

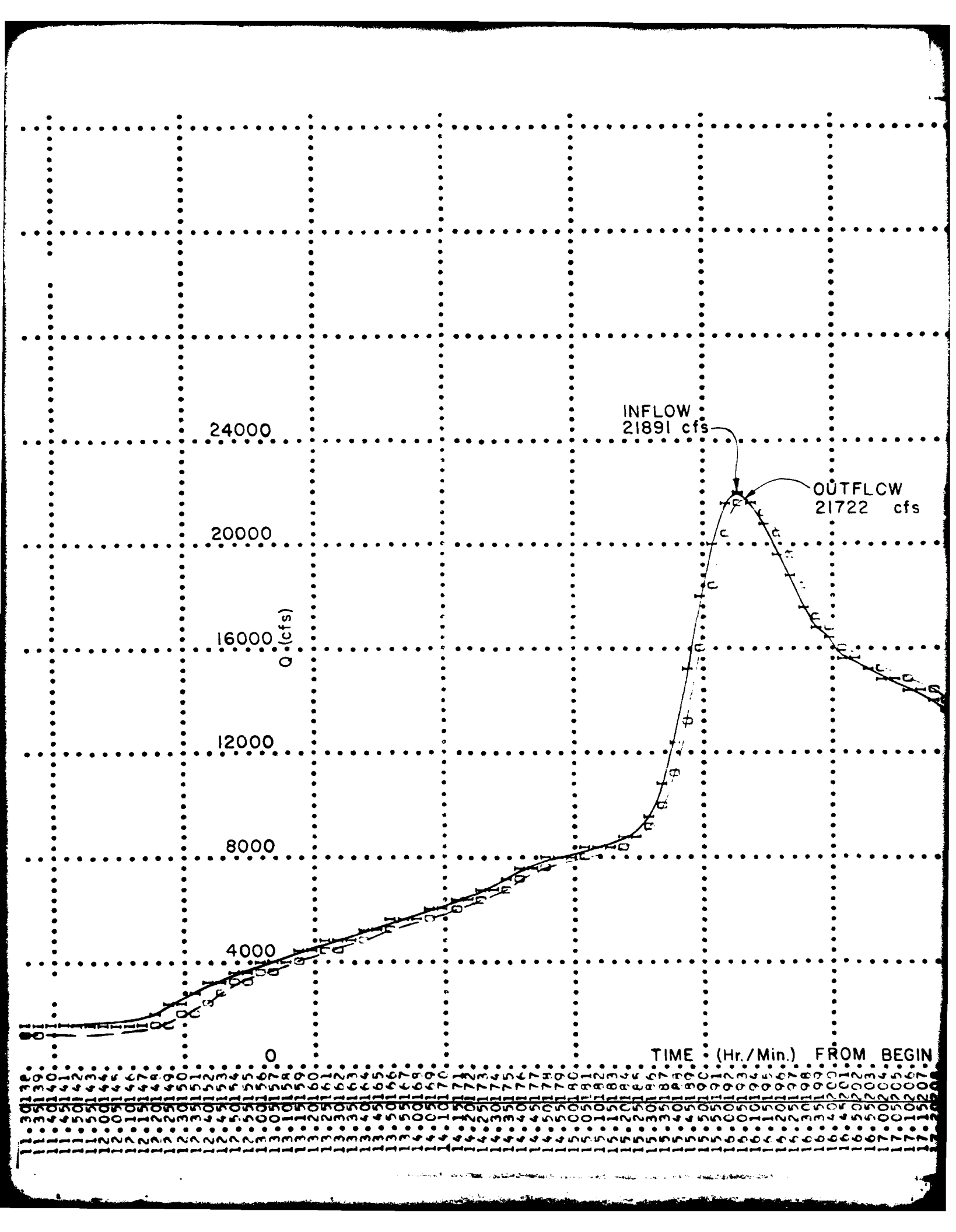
	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	727.00	727.00	731.30
STORAGE	107.	107.	174.
OUTFLOW	0.	0.	1920.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	731.64	.34	180.	2242.	.42	15.92	0.00

SUMMARY OF DAM SAFETY ANALYSIS
10-YR. FLOOD

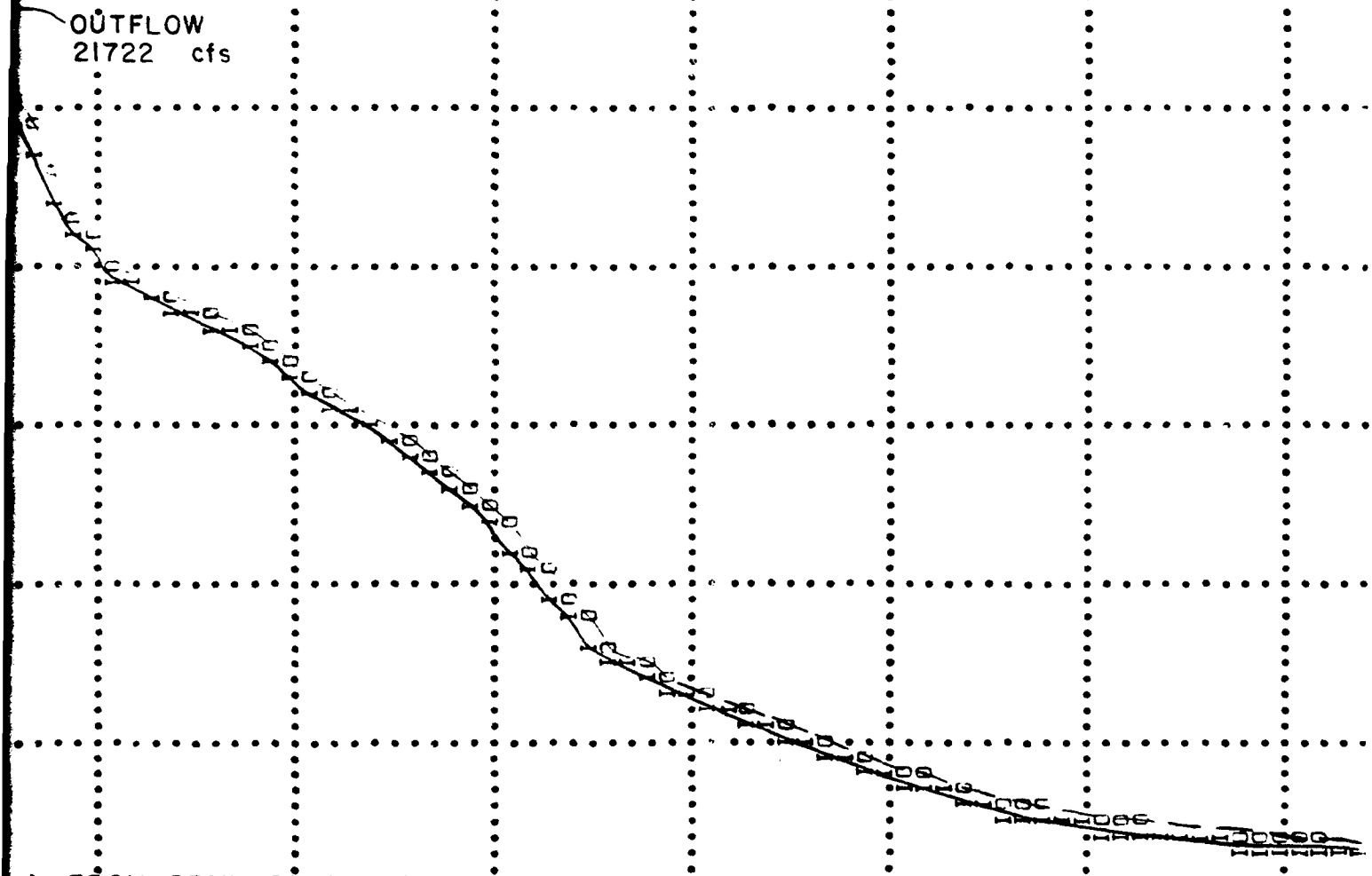
	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	727.00	727.00	731.30
STORAGE	107.	107.	174.
OUTFLOW	0.	0.	1920.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	729.78	0.00	143.	1007.	0.00	16.00	0.00


INFLOW
21891 cfs
OUTFLOW
21722 cfs
24000
20000
16000
12000
8000
4000
0
Q (cfs)
TIME (Hr./Min.) FROM BEGIN

POWDER SPRING LAKE
PMF INFLOW & OUTFLOW
HYDROGRAPHS

Horner & Shifrin, Inc. Mar. 1980



h.) FROM BEGIN OF RAINFALL


DAT
ILM